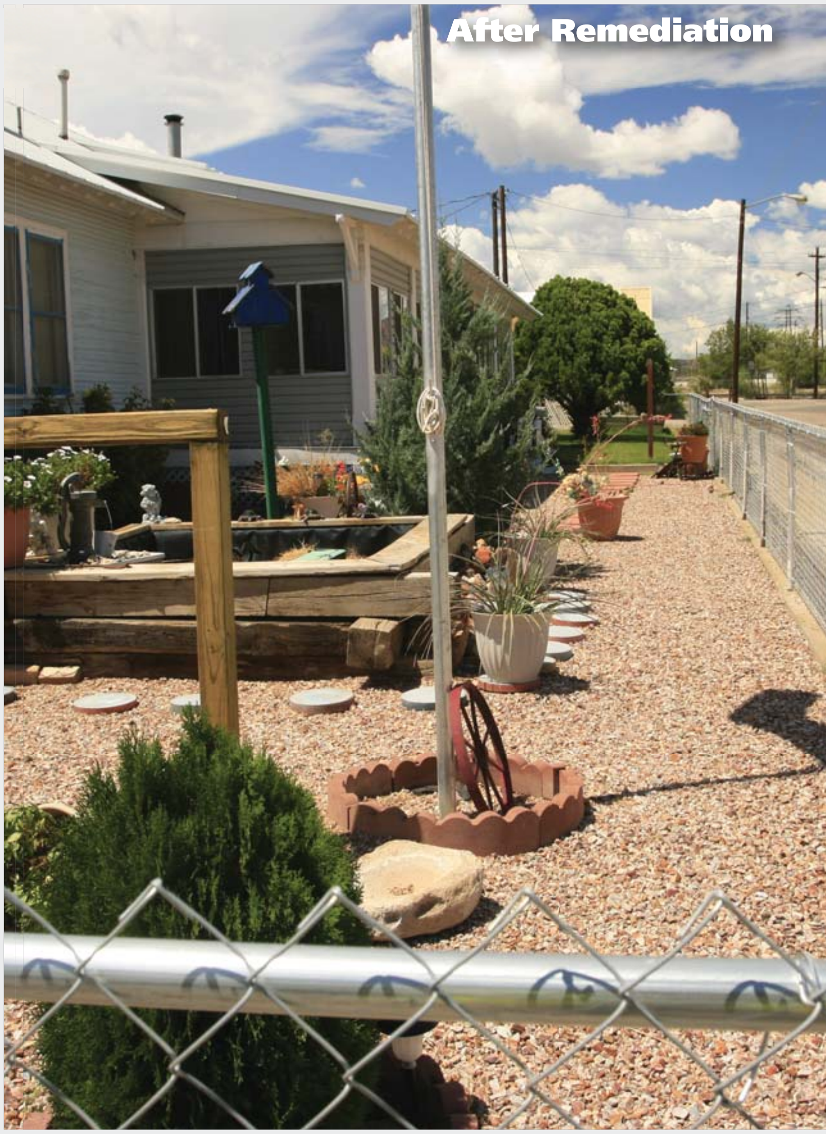
Administrative Order on Consent Feasibility Study for the Hurley Soils Investigation Unit



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FEASIBILITY STUDY
FOR THE
HURLEY SOILS INVESTIGATION UNIT

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1.0 INTRODUCTION

This Feasibility Study (FS) for the Hurley Soils Investigation Unit (HSIU) was prepared pursuant to the Administrative Order on Consent (AOC) between the Chino Mines Company (Chino) and the New Mexico Environment Department (NMED), effective December 23, 1994. This documents the identification, evaluation, and detailed analysis of remedial alternatives for the HSIU.

1.1 Background

The HSIU is one of the Investigation Units identified within the Investigation Area (IA) of the AOC. The IA includes all areas in which environmental media may have been affected by historic operations at Chino's copper mining and processing facilities in Grant County, New Mexico.

In accordance with the AOC Scope of Work, a Remedial Investigation (RI) for the HSIU was conducted to generate the data necessary to evaluate the potential effects to human health and the environment from historically affected media in the HSIU, as described in Section 2.6.2. A human health risk assessment (HHRA) was conducted to provide estimates of human health risks associated with exposure to investigation constituents in Hurley soil, as described in Section 2.6.3.

On July 27, 2005, NMED issued the pre-Feasibility Study Remedial Action Criterion (RAC) for the HSIU of 5,000 mg/kg copper in soil. This RAC was developed based on the evaluations conducted in the RI and the HHRA. Further details about the RAC are presented in Section 3.2.

An Interim Remedial Action (IRA) was conducted in Hurley. This action was preceded by a Pilot Program in the summer of 2005 (Section 2.6.5). The IRA began in February 2006 and was completed in July 2007. The IRA consists of remediation of properties with soil containing copper concentrations greater than the RAC. Further details about the IRA are presented in Section 2.6.6.

1.2 Purpose and Scope

The purpose of this Feasibility Study (FS) is to identify and evaluate the remediation alternatives appropriate for the HSIU and to conduct a detailed analysis of the alternatives in accordance with the AOC. This allows informed decision making regarding selection of a remedy for the HSIU.

1.3 Summary of the FS Process

In accordance with Environmental Protection Agency guidance (EPA 1988), an FS is generally conducted in the following steps:

1. Establishment of RAC for constituents and media of interest. This step has been completed, as described above.
2. Identification of the applicable general response actions (e.g., containment, removal, or treatment).
3. Estimation of the quantities associated with various remediation activities.
4. Identification and screening of potentially applicable technologies for each affected medium to obtain a set of technologies feasible for use in achieving RACs.
5. Assembly of retained technologies into remedial alternatives that cover the full range of possible response actions.

6. Evaluation of alternatives in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) requirements as embodied in seven criteria (40 CFR 300.430(e)(9)), as follows: overall protection of human health and the environment; compliance with applicable standards; long-term effectiveness and permanence; reduction of toxicity, mobility and volume through treatment; short-term effectiveness; implementability; and cost.
7. Identification of the most appropriate alternative(s) as a remedy for the investigation unit.

1.4 Report Organization

This FS report is organized into the following sections:

- **Chapter 1, Introduction -** This chapter.
- **Chapter 2, Site Summary -** This chapter presents background on the site to support the evaluation of technologies and alternatives.
- **Chapter 3, Remedial Action Objectives -** This chapter identifies applicable standards which, together with the RAC, are used to develop remedial action objectives (RAOs). The RAOs then serve as the standards against which the potential technologies and alternatives are evaluated.
- **Chapter 4, Identification and Screening of Potentially Applicable Technologies -** This chapter identifies and screens potential remediation technologies to develop and screen a list of technologies applicable to the Hurley HSIU.
- **Chapter 5, Assembly and Development of Alternatives -** This chapter assembles the remediation technologies into alternatives to meet the RAOs. The alternatives are developed in sufficient detail to allow evaluation against the RAOs and AOC criteria.
- **Chapter 6, Evaluation of Alternatives -** In this chapter, the remediation alternatives are evaluated against the RAOs and AOC criteria. The alternatives are compared to each other based on the criteria evaluations to provide a basis for selecting a remedy.
- **Chapter 7, References -** This chapter cites the documents referenced in the body of this report.

2.0 SITE SUMMARY

This chapter presents an historical overview of the HSIU, outlines the conceptual site model, and summarizes the work conducted to date under the AOC for the HSIU.

2.1 Site Location and Description

The HSIU consists of the town of Hurley and the unincorporated residential areas north of Hurley (North Hurley), as shown on Figure 2-1. The HSIU includes only those areas that are residential or are regularly used by residents (i.e. parks, public facilities) within these areas. Areas outside the HSIU boundary are being evaluated under the Smelter/Tailings Soils IU.

The town of Hurley is located directly adjacent and to the west of the Hurley Operations Area. Old tailing areas (including Lake One) are located to the east and southeast of the Hurley Operations Area and extend about 5 miles to the southeast.

The town of Hurley grew as a company town associated with the Hurley concentrator, which was built in 1911. As the population of Hurley expanded, additional residential housing was constructed in 1938 to the north of the rail spur. In 1955, the town of Hurley was incorporated and property ownership was distributed among the town residents.

The town of Hurley consists of residential town blocks laid out in a uniform manner. The southern portion of the town of Hurley (the area south of the rail spur) consists of housing laid out uniformly within each town block with about 12 residences per block, except where schoolyards or parks occur. The northern portion of the town (north of the rail spur) was also laid as town blocks, but the houses in this area are smaller and more closely spaced than in the southern portion. There are approximately 690 residential and non-residential properties in the town of Hurley. North Hurley consists of residential housing situated in loose clusters that extend to the end of North Hurley Road.

2.2 Historical Operations

Open pit mining operations at Santa Rita began in 1910 and have continued and expanded to the present. In 1911, the Chino Copper Company constructed a crushing plant, concentrator, and power plant at the Hurley Industrial Area, to which the ore was transported from Santa Rita by rail.

Concentrate from the Hurley Concentrator was transported off-site for smelting until 1939 when the Hurley Smelter was completed (Figure 2-2). Once the smelter began operation, copper concentrate was loaded into underground storage bins west of the main smelter building, and stockpiled adjacent to the bins when the capacity of the bins was intermittently exceeded. Copper precipitate was transported to the smelter site by rail and was blended with copper concentrate prior to the smelting process. A temporary drying area for copper precipitate was located adjacent to the concentrate stockpile area (Chino 2004). A covered concentrate blending plant was constructed in 1980 to store and mix concentrate and precipitate.

The Hurley Concentrator ceased operations in 1982 (when the Ivanhoe Concentrator began operation at the Santa Rita Pit) and was dismantled in 1988. Upon shutdown of the concentrator, transport of ore from the mine ceased, the shipping of copper concentrate through slurry lines began. A filter plant was constructed in Hurley to dewater the concentrate slurry. Production of copper precipitate ceased in 1997 after the shutdown of the Precipitation Plant.

The smelter was in continuous operation at Hurley from 1939 to 2002. The original smelter used one reverberatory furnace and two Pierce-Smith converters to produce blister copper, and relied on a 500-ft stack for furnace emissions. Chino constructed a 626-ft high stack for exhaust gas from the converters in 1967. The 500-ft stack continued to be used for reverberatory furnace gas until 1984 when the furnaces were replaced with an INCO flash furnace (Chino 2004). All furnace, converter, and acid plant exhaust gases were vented to the 626-ft stack from that time.

In 1984, Chino completed a major modernization of the smelter facility (Chino 2004). Significant improvements to the smelter and ancillary facilities included the following:

- Construction of an oxygen plant to supply the INCO flash furnace;
- Redirection of tail gas from the acid plant to the 626-foot stack, and demolition of the 200-foot acid plant tail gas stack;
- Modification of the acid plant to increase its capacity to process the converter off-gases and off-gas directly from the INCO flash furnace; and
- Installation of secondary hoods on each converter to improve containment of fugitive gases and dusts.

Since the completion of the smelter modernization in 1984, Chino implemented several additional improvements, including environmental controls. Specific examples of upgrades include:

- Replacement of the fire-refining furnace and ingot wheel with an anode casting circuit;
- Construction of a metals recovery system for the filtrate from the concentrate filter plant and other sources;
- Construction of a facility for rail unloading of purchased concentrate;
- Improvements to the gas cleaning circuits for the INCO flash furnace and converters;
- Expansion of the enclosed concentrate blending plant;
- Installation of a baghouse to capture particulate emissions from the converter secondary hood gas collection system.

Under normal operating conditions at the smelter, copper bearing material was smelted into copper anodes which were transported off-site for refining. The smelter was dismantled in 2007.

Tailings have been transported and deposited in tailing impoundments south of Hurley since 1911. These impoundments encompass an area that stretches 5.3 miles to the south-southeast of Hurley. The old tailing areas (including Lake One, Tailing Pond 1, 2, B, C, 4, 6E, and 6W) are currently inactive and dry. As described in the AOC Background Report (Chino 1995), Lake One was previously used as a water source in the ore-flotation process and other reduction operations for the Hurley Concentrator. Lake One was filled with tailing from the Hurley Concentrator in the 1980s.

2.3 Current Operations

Current mining-related operations near Hurley include the power plant, filter plant, and tailing impoundments located to the south of the town. Operational areas described below are covered by discharge permits issued by NMED and are not included in the AOC.

The Lake One impoundment area south of Hurley operates under DP-214, which was renewed on January 11, 2006. Lake One was used as a staging area for soil excavated from Hurley properties. Lake One closure is not included in the AOC, as it is covered under DP-1340.

Under DP-484, tailing from active mining operations are currently being placed at Pond 7, which is located south of Lake One.

The AOC addresses potential historic releases to the environment that may not be covered under other regulatory programs. Several operating permits are in place within the Hurley Operations Area and tailing facilities that regulate air emissions and discharges to both groundwater and surface water. Specifically, existing regulatory compliance programs include the following state and federal requirements:

- New Mexico Air Quality Control Regulations;
- Clean Air Act Title V Permit Program;
- New Mexico Water Quality Control Commission Regulations;
- National Pollution Discharge Elimination System (NPDES); and
- New Mexico Mining Act.

2.4 Physical Setting

The HSIU is located in the San Vicente Basin, which is a broad lowland characterized by several sandy-bottom dry washes and gullies. The town of Hurley is situated on a relatively flat plain at an elevation of approximately 5,700 ft above mean sea level.

2.4.1 Meteorology

The Hurley area is located in a semi-arid region with relatively low humidity. The estimated open-water evaporation rate in the region is about five times the average annual precipitation rate. The average annual precipitation for Hurley is 15.4 inches as measured at the Hurley station, falling mostly during the summer months, typically in the form of brief but occasional high-intensity thunderstorms. The average annual temperature at Fort Bayard (located about 6 miles north of the town of Hurley) is 55.1° F, and average monthly temperatures range from 38.4 ° F in January to 72.5 ° F in July. The prevailing wind direction is from the west-northwest, averaging 6 to 12 mph in the spring and 5 to 9 mph during the rest of the year (Chino 1995).

2.4.2 Soil

2.4.2.1 Native Material

Information from the U.S. Department of Agriculture, Natural Resources Conservation Service (NRCS) indicate that agriculture has not been pursued on a large scale in the immediate area due to the relatively dry climate, varying topography, and poor soil conditions. Soil is generally rocky and thin, with little organic material (Chino 1998).

The predominant soil type in the HSIU area is the Plack-Lonti-Pit soil, which is predominately a loam type soil. A crusted calcium or magnesium carbonate layer (caliche) due to evaporation/precipitation is present in the shallow subsurface throughout most of the HSIU. The depth to the caliche has been determined through field observation at about one inch to one foot below ground surface (Chino 1998).

2.4.2.2 Amended Soil

Many yards, recreational areas, and gardens contain soil that has been amended to sustain vegetation, or to allow other uses. Amended soil consists of native soil that has been modified by tilling, soil amendments, or has been modified by the introduction of non-native materials such as topsoil, sod, or sand. The depth of the amended soil varies with each property. For example, gardens are amended to the depth necessary for the vegetables grown in that particular garden (e.g., 0” to 6”), whereas other yards may contain a thin layer (e.g., 1” to 3”) of imported organic material or sod to support a lawn. The source of the imported materials is unknown, but it is expected that there are numerous sources.

Soils from developed recreational areas, such as parks and ball fields, typically exhibit lower concentrations of most constituents regardless of location (Chino 1998). Similarly, well maintained yards or gardens that have been actively modified contain lower concentrations of copper and other constituents.

2.4.3 Surface Water

The Whitewater Creek drainage basin covers an area of approximately 57 square miles and ranges in elevation from 5,300 to 7,600 ft above mean sea level. Runoff from the upper Whitewater Creek is prevented from entering the Santa Rita pit by intercepting the creek with a reservoir and diversion system. The active creek begins west of the Santa Rita concentrator and continues west-southwest toward Bayard, then turns to the south.

There is little open surface water in the HSIU. In minor rain events, surface water infiltrates into local soils. In major rain events, surface water collects in drainage ditches and drains toward the south end of town. Water in drainages typically infiltrates into soil before entering Whitewater Creek.

Whitewater Creek is located approximately 150 ft east of the northernmost residences in North Hurley and veers east and runs along the eastern side of the Hurley Industrial Area (Figure 2-1). Field observations indicate that surface water flow in Whitewater Creek occurs only ephemerally after significant rainfall events. Runoff events in the upper reaches of Whitewater Creek typically infiltrate into the stream bed before reaching the HSIU (Chino 1998).

2.4.4 Groundwater

Groundwater in the vicinity of the HSIU is currently regulated and routinely monitored under discharge plans (DP-214, Whitewater Creek) for the smelter. Drinking water is supplied by Chino to all residents within the HSIU via wells completed in the Gila Conglomerate, a geologic formation consisting of poorly sorted sediments ranging in size from clays and silts to cobble-sized grains. As reported in the Phase I RI Report (Chino 1998), water level elevations recorded during March, 1998, indicate that the depth of the groundwater table beneath the Town of Hurley ranges from 140 feet to greater than 188 feet below ground surface. Groundwater in the Gila Conglomerate appears to flow in a southeasterly direction beneath the Town of Hurley with a horizontal hydraulic gradient of approximately 0.015.

2.5 Conceptual Site Model

The conceptual site model (CSM) was developed as part of the Phase I RI (Chino 1998) to illustrate the potential sources of constituent releases, release mechanisms, the media possibly affected by releases, and the possible human exposure routes for the HSIU. The CSM identifies the pathways that transport site constituents in environmental media (Figure 3-1). In the FS, the CSM is used to evaluate the effectiveness of each remedial alternative in addressing each potential pathway for human exposure.

The CSM for the HSIU identifies historical mineral processing operations as the potential sources of constituent releases to soil in the HSIU (Figure 3-1). All other potential sources of site constituents are monitored and addressed under discharge plans. The CSM illustrates that historic fugitive dust and particulate emissions from historical mineral processing operations may have affected Hurley soil.

Fugitive dusts and particulate were released from mineral processing sources in the Hurley Operations Area by physical solids handling operations (including milling, mixing, loading, and moving of solids related to mineral processing) and by wind erosion of mineral-related solids creating airborne particulate.

Particulates were released from mineral processing sources via air. The predominant wind direction in Hurley is toward the southeast, which positions Hurley generally upwind of the major mineral processing sources. Airborne particulate was likely transported and deposited in Hurley during both windy and calm conditions. The airborne particulate was deposited by gravity settling, which results in large-sized particulate settling closer to the sources than smaller-sized particulate. This type of deposition occurs during both windy and calm conditions. This typically results in a higher mass of particulate being deposited on soil near the sources, and decreasing mass with increasing distance from the sources.

In the Phase I RI for the Hurley Soils IU (Chino 1998), it was demonstrated that historical mineral processing activities adjacent to the town of Hurley resulted in affected soil in the Hurley Soils IU. Hurley soil is therefore a secondary source of constituents related to mineral processing activities. Constituents in Hurley soil may potentially be released to human exposure and to the environment via the following release mechanisms and exposure pathways:

- Direct contact/direct contact and ingestion of constituents in surface soil;
- Resuspension to air/inhalation of constituents in air;
- Absorption to homegrown garden foods/ingestion of constituents in garden foods;
- Runoff to surface water and sediments/ingestion and direct contact with constituents in surface water and sediment; and
- Infiltration to groundwater/ingestion and direct contact with constituents in groundwater.

All of the potential exposure pathways identified above were evaluated in the RI. The direct contact with Hurley soil pathway was retained as a complete pathway, as direct contact and ingestion exposures are possible in Hurley.

All other pathways were eliminated from further consideration in the RI for the following reasons:

- A complete pathway does not exist, or is negligible (ingestion and direct contact with surface water and sediment);
- Observed risk-based concentrations did not exceed screening levels (ingestion of homegrown garden vegetables, and inhalation of resuspended Hurley soil); and
- Pathway is evaluated under another IU (the groundwater pathway is evaluated under the Comprehensive Groundwater Characterization Study [CGCS]).

2.6 AOC Activities

2.6.1 Background Investigation

A Background Investigation was conducted in 1995 to evaluate existing data, and to collect data to assist in the development of RIs in each IU under the AOC (Chino 1995).

A reference soil investigation was conducted as part of the Background Investigation to identify investigation constituents in Hurley. Surface soil samples were collected in areas unaffected by mineral processing operations (i.e., reference areas) to quantify background levels of constituents. Reference surface soil concentrations were compared to HSIU surface soil concentrations to identify investigation constituents using the Wilcoxon Rank Sum (WRS) test, in accordance with Environmental Protection Agency (EPA) guidance (EPA, 2000). A constituent was eliminated as a possible investigation constituent when there was probability that the distribution of Hurley soil concentrations was less than the distribution of reference concentrations. The remaining constituents were identified as investigation constituents. The investigation constituents for the HSIU were arsenic, barium, cadmium, cobalt, copper, lead, manganese, molybdenum, selenium, silver, and zinc.

Table 2-1 presents a comparison of concentrations of investigation constituents to reference surface soil concentrations.

2.6.2 Remedial Investigation

The HSIU RI/FS was initiated in 1995, and provided environmental data that were used, among other things, to characterize effects from historical mineral processing on residential soils in the HSIU. The RI was conducted in several phases, as shown in Table 2-2.

The soil sampling analytical results for the HSIU were compared to decision criteria developed for the HSIU (Chino 1998). The decision criteria for the residential soil ingestion pathway became the risk driver for the human health risk assessment, and are therefore summarized in this section (Table 2-3). The decision criteria were developed at the time of the Phase I RI primarily using EPA Region III risk-based screening levels (EPA 1995), which used relatively conservative default exposure parameters to estimate cancer and non-cancer effects from ingestion of soil in a residential setting. The screening levels used an acceptable cancer risk of one cancer in a population of one million, and non-carcinogenic decision criteria based on a hazard quotient of 1.0. As an update from the RI, Table 2-3 also includes current EPA Region VI Human Health, Medium-Specific Screening Levels 2006 for comparison against Hurley concentrations, as published in the following website:

- (http://www.epa.gov/earth1r6/6pd/rcra_c/pd-n/screen.htm)

The results presented in Table 2-3 show that the maximum concentrations of arsenic, copper, lead and manganese in Hurley soil exceeded the decision criteria for residential land use. Measured copper concentrations in Hurley soil can be directly related to historical mineral processing sources, as predicted by the CSM in Section 2.5. However, arsenic and lead are poorly related with copper, and the spatial distribution of these metals indicates that these metals are likely related to both historical mineral processing sources and other residential sources. Manganese is not related by either visual or statistical analysis to historical mineral processing sources. Arsenic, lead and manganese do not fit the CSM, as described in Section 2.5.

The results for the North Hurley area indicated that investigation constituents were present at concentrations that were well below the decision criteria for all constituents except arsenic as a cancer endpoint (the arsenic non-cancer endpoint was not exceeded). However, 12 of the 17 observed North Hurley arsenic concentrations were below the reference arsenic concentration for Hurley (3.1 mg/kg), as described in the HSIU RI Proposal (Chino 1997). Because of the distance of North Hurley from the historical sources and the poor correlation of arsenic with other investigations constituents, arsenic was considered sporadically distributed, and likely influenced by residential land uses. North Hurley was dropped from further consideration in the RI.

The results of the RI showed that copper concentrations were elevated in Hurley, with relatively high copper occurring in the northern and eastern areas of the town. Concentrations decreased with distance from the historical sources, as predicted by the CSM. As shown in Figure 3-2, the copper concentrations that exceeded 5,000 mg/kg occurred primarily in the east to center of the northern area of Hurley; and on the eastern side (primarily east of 1st Street) in the southern area of Hurley.

Several Phase II RI activities were conducted to further characterize the soil within the HSIU and to provide additional data to refine the human health risk assessment (as described below), including a lead-based paint study (Chino 2000), a homegrown garden vegetable study (Chino 2001), and a Bioaccessibility Study to determine copper solubility (Chino 2002).

For each phase of data collection there exists a proposal and sampling plan documenting the approach, rationale, and methods of implementation and a subsequent report documenting the data collection activities, results, and conclusions for that phase of the investigation. The phases of the HSIU RI and related proposals and reports are listed in Table 2-1.

2.6.3 Human Health Risk Assessment

A human health risk assessment (HHRA) was conducted by Gradient Corporation (Gradient) for the NMED to provide estimates of potential risk to residents of the HSIU from affected soils based on RI data. The deterministic risk assessment concluded that some of the elevated copper concentrations in HSIU soil could potentially pose an unacceptable risk to human health (Gradient 2000). The risk assessment was conducted following the EPA guidance model for chronic exposure to metals in soil with copper as the primary risk driver for the HSIU.

The risk assessment identified human health effects from ingestion of copper in solution, based on studies of ingestion of copper sulfate in water. The health effects include acute gastrointestinal effects such as nausea and vomiting. These effects are typically transient and reversible, and, since the effects are acute effects, do not follow the chronic model typically used to assess human health risk.

Gradient revised their risk assessment to incorporate additional data collected from Phase II RI activities, to include an estimate of copper solubility in soil, to incorporate Chino comments on the risk assessment, and to provide a model of acute rather than chronic effects from incidental copper ingestion. Gradient used Monte Carlo simulations to provide a probabilistic evaluation of potential risks in the HSIU, as reported in an addendum to the risk assessment submitted to NMED on December 19, 2003 (Gradient 2003).

The goal of the evaluation was to identify a RAC that would result in a low probability (i.e., 2.5% or 5%) of a child experiencing five or less nausea episodes per year. The results of the Monte Carlo simulation provided probability estimates used by NMED to develop RAC for the HSIU.

2.6.4 Pre-FS Remedial Action Criteria

On July 27, 2005, NMED issued the pre-Feasibility Study Remedial Action Criterion (RAC) for the HSIU of 5,000 mg/kg copper in soil. This RAC was developed based on the evaluations conducted in the RI and the HHRA.

The pre-FS RAC states that "through the HHRA process, copper was found to be the only contaminant of concern posing a risk and subsequently became the primary focus of the HHRA". The Pre-FS RAC was developed to be protective of the population of Hurley. In particular, the RAC is intended to be protective of children who incidentally ingest copper in Hurley soil.

The Pre-FS RAC was issued with the following conditions:

- Chino shall identify all residences in the town of Hurley with children under the age of 8 years of age and provide this information to the NMED;

- Chino shall develop a public health advisory that describes the extent of copper soil contamination in Hurley, describes the potential health risks associated with ingestion of copper; and requesting that anyone experiencing health concerns associated with nausea or gastrointestinal issues to contact NMED.

Chino collected data on the number of children under age eight during the course of the Hurley Interim Remedial Action (IRA), and the transfer of this information to NMED is in progress. Chino conducted a certified letter mailing to Hurley residents and property owners to provide a Public Health Advisory for Copper in Hurley Soil. A copy of this advisory is presented in Appendix B of the Hurley IRA Completion Report (Chino 2008).

2.6.5 Hurley Pilot Program

A Pilot Program was conducted in the summer of 2005 to remediate four properties in Hurley. The remediation was conducted per the NMED-approved work plan (Chino 2005). In addition, several testing and analytical methods and techniques were performed to test feasibility and implementability. These tests are described in detail in the Hurley IRA Work Plan (Chino 2006). The results of the Pilot Program were reported in the Hurley IRA Completion Report (Chino 2008), as described in Section 2.6.6.

2.6.6 Hurley Interim Remedial Action

An Interim Remedial Action (IRA) was conducted in the HSIU, per the Work Plan submitted to NMED (Chino 2006). The IRA consisted of an evaluation of soil within the HSIU and remediation of soil that exceeds the RAC of 5,000 mg/kg copper in soil. The objective of the IRA was to achieve the RAC throughout the HSIU.

The Hurley IRA Completion Report (Chino 2008) documented the activities and results of the Hurley IRA, and the data collected, analyzed, and validated for the Hurley IRA to confirm that all appropriate response actions have been completed at this IU. Any areas within the HSIU that were not subject to the IRA Work Plan were identified and documented by Chino in the Completion Report, and approved by NMED on a case by case basis. The IRA consisted of four primary elements:

1. **Round 1 Characterization** – Sampling and analysis to evaluate the soil within the HSIU to identify areas where the RAC are exceeded and remediation is needed;

2. **Removal** – Excavation of soil in areas where the RAC is exceeded;

3. **Round 2 Characterization** – Confirmation sampling of soil remaining after excavation to verify that the RAC has been achieved; and

4. **Restoration** – Backfilling and restoration of landscaping upon clearance from confirmation sampling.

Further rounds of removal, followed by additional rounds of soil characterization, occurred if confirmation results indicate that the RAC was not achieved.

3.0 REMEDIAL ACTION OBJECTIVES

Remedial action objectives (RAOs) are site-specific remediation goals that define the desired outcome of actions taken to reduce human health or environmental risk due to site constituents of concern. RAOs are developed considering the following elements: the conceptual site model (CSM) for human exposure, acceptable exposure levels that are protective of human health and the environment and comply with applicable standards (ASs), and Pre-FS RAC issued by the NMED.

RAOs identify potential risk pathways that remedial actions should address. Removal of either the exposure media or exposure route constitutes a method of protecting potential receptors.

3.1 Applicable Standards

The AOC defines Applicable Standards (ASs) as Federal and State environmental laws, regulations, standards, requirements, criteria, guidelines or limitations that are legally applicable or relevant and appropriate.

A preliminary identification of ASs for the AOC Investigation Area was presented in the Background Report (Chino 1995). The ASs that are potentially applicable or relevant and appropriate for the HSIU were presented in the RI Report (Chino 1998).

In accordance with the AOC, the NMED used the ASs contained in the approved RI Report, as well as information generated from the HHRA, to develop pre-FS RAC. The pre-FS RAC were issued by the NMED in July 2005, as described in Section 2.6.4.

3.2 Remedial Action Objectives (RAOs)

The Pre-FS RAC for the HSIU is 5,000 mg/kg copper in residential soil. This is the action level for the HSIU.

Based on the Pre-FS RAC and applicable standards, the RAOs for the Hurley HSIU are:

- Prevent incidental ingestion of soil containing copper originating from historical mineral processing activities adjacent to the Town of Hurley in concentrations greater than 5,000 mg/kg.

4.0 IDENTIFICATION AND SCREENING OF POTENTIALLY APPLICABLE TECHNOLOGIES

This chapter identifies and screens technologies that may be included in remediation alternatives for the HSIU. A comprehensive list of technologies and process options that are potentially applicable to this site is developed to cover all the applicable general response actions. The list of technologies is then screened to develop a refined list of potentially feasible technologies that can be used to develop remediation alternatives for the site. Brief descriptions of the potential remediation technologies for the HSIU and discussions of the screening results are provided below.

1. Identification of the applicable general response actions (e.g., containment, removal, or treatment).
2. Estimation of the quantities associated with various remedial activities.
3. Identification and screening of potentially applicable technologies for each affected medium to obtain a set of technologies feasible for use in achieving RACs.

4.1 General Response Actions

General response actions (GRA) are broad categories of remedial actions that can be combined to meet remedial actions at a site, and are summarized in Table 4-1. The following general response actions are generally applicable to most sites, including the HSIU, and provide a context for identifying applicable technologies (AT):

- No Action (GRA-01);
- Institutional Controls (GRA-02);
- Monitoring (GRA-03);
- Containment (GRA-04);
- Excavation and Disposal (GRA-05);
- In Situ and Ex-Situ Treatment (GRA-06); and
- Reuse and Recycling (GRA-07).

Except for "No Action" (GRA-01), each of these general response actions may be addressed with one or more technologies.

4.2 Estimation of Quantities Associated with Remedial Activities

The quantities associated with remedial activities was estimated based on data collected during the RI and the Pilot Program (Section 2.6.5). The Hurley IRA provided more detailed information on the areas and volume of affected media.

As summarized in the Hurley IRA Completion Report (Chino 2008), the entire area of the town of Hurley was characterized to determine whether soil exceeded the RAC and required remediation. A total of 520 properties and 60 alley and easement areas were remediated in Hurley. The area of land remediated in each property or alley and easement area was variable. The depths of excavation were also variable, ranging between three inches and one foot. Approximately 40,000 cubic yards of excavated soil was removed from Hurley over the course of the IRA.

4.3 Identification and Screening of Applicable Technologies

Applicable Technologies (AT) that are typically considered for addressing each general response action are described in the following sections. These technologies were screened based on:

- HSIU physical conditions;
- Media and exposure pathways of concern, as established in the RAOs;
- Socio-economic considerations; and
- Status of the technology, to eliminate those technologies that are insufficiently developed, require unreasonable time periods for completion, etc.

4.3.1 <u>Institutional Controls (GRA-02)</u>

Institutional controls are legal and administrative restrictions to prevent exposure to chemical constituents at a site. Risk is eliminated by institutional controls to the extent that they prevent exposure to affected media. Some form of institutional control is typically included in those remedies where contaminants of concern (COCs) above actions levels will remain after remediation activities have been completed.

4.3.1.1 Land Use Restrictions (AT-02)

Land use restrictions are legal controls, such as zoning or deed restrictions, which establish allowable and prohibited development or activities at a site. Deed restrictions are notices of land use restrictions that accompany the deed to the property in a manner that is legally binding and must be transferred to all subsequent owners of the property. The restrictions would include a description of the site and reasons for the limits on future activity. Such restrictions would prohibit activities or development that could cause direct exposure to COCs or that could compromise the integrity of the remedy.

For the HSIU, land use restrictions would be necessary in conjunction with those technologies that leave potentially accessible COCs above action levels in place, such as containment. These restrictions would be needed on residential property not owned by Chino.

4.3.1.2 Public Education (AT-03)

Due to the residential nature of the HSIU, activities to educate Hurley residents will be a necessary component of any remedial action. In addition, public education would be a key component of any remedy that leaves potentially accessible COCs above action levels in place, because the cooperation of residents would be necessary for implementing and maintaining the remedy.

Public education would include presentations to Hurley residents and landowners to explain the remedy prior to and during implementation of a remedial action, and/or mailings to town residents and property owners. Continuing public education could be used to increase the level of cooperation in maintaining and monitoring remedies that leave potentially accessible COCs above action levels in place, such as containment.

The public health advisory stipulated as part of the Pre-FS RAC will be an element of the public education initiative for any remedy.

4.3.2 Monitoring (GRA-03)

The applicable technologies for monitoring include short-term and long-term monitoring.

4.3.2.1 Site Monitoring (AT-04)

Short-term monitoring is conducted to ensure that potential risks to human health and the environment are controlled while the selected remedy is being implemented and to provide quality control. Short-term monitoring would be conducted regardless of the remedy chosen and typically consists of observation during remedial construction, supplemented by activities such as air monitoring, medical surveillance, and the like on an as-needed basis.

Long-term monitoring would be necessary only for those remedies where affected soil with COCs above the action level would remain on-site and potentially accessible after completion of the remedy. Such monitoring would be performed to verify that the remedy continues to be protective of human health and the environment, and to allow timely maintenance of permanent physical components of the remedy.

4.3.3 Containment (GRA-04)

In-situ containment is a general response action used (1) to prevent exposure to material containing COCs that are left in place and (2) to control migration of COCs. The following containment technologies are considered potentially applicable to the HSIU.

4.3.3.1 Soil Cover (AT-05)

A clean soil cover placed over copper-contaminated soil would minimize the potential for ingestion or other direct contact with the affected soil and would prevent resuspension of affected soil in air or surface water runoff. However, the effectiveness of a soil cover could be compromised by digging or other activities that penetrated the cover. The cover thickness would need to be large enough to reliably prevent contact with underlying soil during normal activities in the yard; a minimum thickness of 6 inches is considered necessary to meet this criterion. However, placing this thickness of soil in a residential yard would be unacceptable due to increasing the elevation, which would interfere with use of the yard and disrupt drainage patterns. Consequently, a soil cover is retained for further consideration only for those technologies that include some excavation but where removal of all soil above action levels is not possible. In these cases, the soil cover would be placed to restore the yard to existing grade, thus eliminating the drawbacks of this technology.

4.3.3.2 Pavement Cover (AT-06)

Asphalt and/or concrete pavement would eliminate the potential for ingestion or other direct contact with affected soil and would prevent resuspension of affected soil in air or surface water. This technology would be highly reliable, because activities which penetrate and disrupt pavement are not expected under normal residential conditions. For this reason, existing pavement will not be removed to remediate underlying soils.

However, installation of pavement over existing soils would result in grade changes and associated problems similar to those for the soil cover, and more significantly would change the existing condition of the affected area. In order to treat every property owner consistently, and thereby enhance public acceptance of the remediation program and facilitate cooperation during remedial construction, the remedial action should not change the physical nature of the affected area any more than necessary. For this reason, pavement covers are not retained for further consideration.

4.3.3.3 Dust Controls (AT-07)

Dust control commonly involves stabilizing surface soils to minimize wind dispersion of affected soils. Dust controls are effective in the short term to minimize inhalation risk, but do not address the ingestion pathway and are not durable enough to provide a long-term remedy. They are retained for consideration as an adjunct to other remedial technologies, but are not retained as a principal remediation technology.

4.3.3.4 Surface Water Controls (AT-08)

Surface water management typically involves preventing surface water run-on to the affected area, which could damage the remedy, and run-off from the affected area, which could transport affected soil off-site. Like dust control, surface water controls do not address the ingestion pathway.

These controls may be used as short or long-term measures. However, because of the low precipitation in Hurley, COC migration in surface water is not a concern for the HSIU. Consequently, surface water controls are not considered a principal remedy but are retained for use in conjunction with other remediation technologies.

4.3.4 <u>Excavation and Disposal (GRA-05)</u>

4.3.4.1 Excavation (AT-09)

Excavation would be performed to remove soils with copper above the action level from residential yards. Removal can be complete or partial. RI data indicate that copper concentrations above the action level generally occur only in the upper few inches of soil, consistent with historical air-born deposition. On this basis, most removal at the HSIU would be expected to be complete. However, if areas of deeper contamination are encountered, for example in thick fills, or excavation depths are limited, for example, by underground utilities, then partial removal may be performed. Excavation is retained for further consideration.

4.3.4.2 Disposal (AT-10)

Disposal at commercial landfills is feasible if the facility is permitted to receive contaminated soil and if the landfill is sufficiently close to allow economic transport. However, no landfills satisfying these criteria have been identified for the HSIU. Nevertheless, other wastes (e.g., yard trash) will be generated during remedial action that require disposal. For some of these wastes, a municipal landfill may be an appropriate disposal alternative. Disposal is retained for further consideration.

With respect to disposal of contaminated soil, Chino has existing stockpiles containing material very similar to the soils which would be excavated from the HSIU. The material in these stockpiles will be recycled in accordance with the AOC and relevant Discharge Plans. Placement of excavated HSIU affected soil on one of these stockpiles would be an acceptable alternative to disposal of HSIU soils. The Reuse and Recycling GRA describes this alternative.

4.3.5 In-Situ and Ex-Situ Treatment (GRA-06)

There are a wide variety of treatment technologies that may be applied in-situ and/or ex-situ for site remediation. Because the HSIU COC is copper, it cannot be destroyed (unlike organic COCs), which eliminates all biological and thermal forms of treatment from consideration. However, chemical and physical treatments are potentially applicable remediation technologies.

4.3.5.1 Chemical Amendment (AT-11)

One approach to the in-situ remediation of contaminated soils is the addition of a chemical amendment to reduce the mobility of the COCs. An amendment, once mixed into the soil in the areas of concern, could change the chemical form of the COC compounds, thus decreasing their mobility in the environment. At the HSIU, there are two potential amendments which are considered feasible from an economic and availability perspective: lime and apatite (fish bones), which might prevent aqueous transport of COCs through a variety of attenuation mechanisms including mineral precipitation and sorption.

An assessment of the relative solubilities of various copper compounds as a function of pH was performed using geochemical model PHREEQC Version 2.8 (Parkhurst and Appelo 1999). This model is an equilibrium speciation and mass-transfer code developed by the United States Geological Survey (USGS), with the ability to simulate mixing of waters, precipitation/dissolution of selected solids, redox reactions, atmospheric interaction, and adsorption of metals onto iron oxides. The MINTEQA2 thermodynamic database was selected because it is considered by many in the geochemical and regulatory communities to be the most accurate geochemical database currently available. The results are shown on Figure 4-1. The results indicate that alkaline amendment can be used to reduce solubility of copper in Hurley soil, provided correct dosing is used. Bench-scale testing will be required to evaluate proper dosages.

An analysis of the copper species present in the HSIU soils was performed for the Bioaccessibility Study (Golder 2002) and is summarized in Table 4-2. These data indicate that approximately 62% of copper in the HSIU exists in the form of sulfides, with 30% in the form of oxides. Based on this study, the bioaccessibility of copper was determined to be about 60%. Addition of soil amendments may bind copper and further decrease its average bioaccessibility in HSIU soil. However, further studies may be needed to adequately support the application of this remedial option at Hurley.

While chemical amendment is very attractive in certain applications, there are significant uncertainties with implementing it in a residential cleanup action and consequently it is not retained for further consideration.

4.3.5.2 Soil Tilling (AT-12)

Tilling would consist of mixing affected surface soils with underlying non-affected or less affected soils. This process would reduce the overall concentration of copper in the mixed soil to below the action level. Because of the limited soil depth above the caliche layer, which is difficult to excavate, and the presence of underground utilities, this approach is not applicable where copper concentrations in surface soils are relatively high and a significant mixing volume would be required. However, in transitional areas between areas above and below the action level, tilling may be appropriate. Soil tilling is retained for further consideration.

4.3.6 Reuse and Recycling (GRA-07)

4.3.6.1 Reuse and Recycling (AT-13)

The affected soil in Hurley contains copper concentrations sufficiently high that recycling (copper recovery) is feasible. Unfortunately, the volume is not large enough to justify the cost and potential emissions from a stand-alone copper recovery facility. However, recycling could be accomplished if excavated soil is placed on existing Chino tailings piles that are proposed for recycling. Reuse and recycling is retained for further consideration.

4.4 Retained Technologies

In summary, the following technologies are retained for the HSIU:

- Institutional Controls (GRA-02);
- Monitoring (GRA-03, ancillary to primary remediation technologies);
- Soil Cover, in conjunction with GRA-04-Containment;
- Dust Controls, in conjunction with GRA-04-Containment, ancillary to primary remediation technologies);
- Surface Water Controls , in conjunction with GRA-04-Containment, ancillary to primary remediation technologies);
- Excavation and Disposal (GRA-05);
- Soil Tilling, in conjunction with GRA-06-In-Situ and Ex-Situ Treatment; and,
- Reuse and Recycling (GRA-07).

A summary of the general response actions is also included in Table 4-1.

5.0 ASSEMBLY AND DEVELOPMENT OF REMEDIATION ALTERNATIVES

In this chapter, remediation technologies retained after screening in Chapter 4 are assembled into remediation alternatives to identify one or more options that will address the remedial action objective. The remediation technologies and alternatives are also presented in Table 5-1. The descriptions provided below include the major activities for each remedy at a sufficient level of detail for the purposes of this FS. Detailed designs, sampling and analysis plans, inspection and monitoring plans, and other documents necessary for implementing the alternative will be prepared at a later date after the remedy has been selected.

Five alternatives have been developed to consider for remediation of the HSIU:

1. Alternative A: No Action.
2. Alternative B: Institutional Controls.
3. Alternative C: Excavation and Reuse.
4. Alternative D: Containment.
5. Alternative E: In-Situ and Ex-Situ Treatment.

5.1 Alternative A – No Action

A "no action" alternative (GRA-01) is included as a baseline for comparison to the other alternatives. This alternative would leave the site in its current state.

5.2 Alternative B – Institutional Controls

In this alternative, a combination of land use restrictions (AT-02), public education (AT-03), and long-term site monitoring (AT-04) would be used to achieve the RAOs. No engineered controls would be included. Private landowners would have to allow necessary institutional controls.

5.3 Alternative C – Excavation and Reuse – C1

This alternative is a combination of excavation (AT-09), disposal (AT-10), and reuse and recycling (AT-13). In this alternative, soil from properties with copper levels above the RAC would be excavated and placed on Lake One for subsequent recycling in accordance with the AOC and pertinent discharge permits. Removal areas would be restored to the original condition or other condition acceptable to the landowner. The major steps in this alternative for a typical residential property are:

1. Sample soils from selected locations on the property and analyze to determine copper concentration.
2. Remove and store personal items within the affected areas of the residential yard, including disposal or recycling unwanted items.
3. If necessary, remove sod or other vegetation on the affected ground surface.
4. Excavate the soil to the identified clean-up depth, generally using small scale equipment or hand removal due to the limited access of residential yards.
5. Use water to suppress dust generated during excavation and soil handling.

5. Use water to suppress dust generated during excavation and soil handling.
6. Transport the soil in trucks to the designated stockpile, taking measures to prevent spillage or dust during transport.
7. Verify that the remaining soil is below the action level by sampling and analysis.
8. Backfill excavated areas with clean soil, landscape gravel, or other material to restore the surface to the original grades.
9. Where applicable, place sod, seeding, or otherwise revegetate the remediated area.
10. Replace the resident's personal property.

No land use restrictions, long-term monitoring, or maintenance would be required for this alternative.

5.4 Alternative D – Containment

This alternative is a combination of excavation (AT-09), disposal (AT-10), and soil cover (AT-05). It is similar to Alternative C, except it would be implemented where removal of all soil above action levels is not possible due to the inability to excavate without high potential for damage (e.g., caliche), underground utilities, and similar factors. The major steps in this alternative are the same as for Alternative C, except for the following modifications:

1. In areas where remaining soil is still above the action level, place a geotextile fabric on the excavated surface prior to backfilling. The fabric would serve as a marker layer to indicate the elevation below which digging should not be performed, and also as a separator to prevent mixing of clean soil with underlying contaminated material due to frost action and other processes. A minimum thickness of 6 inches of clean soil would be placed over the geotextile.
2. Maintain and monitor the cover.
3. Implement institutional controls.

The property owners would be responsible for long-term maintenance of the cover; this requirement would be documented in deed records and/or other appropriate legal documents.

5.5 Alternative E – In-Situ and Ex-Situ Treatment D

This alternative consists of soil tilling (AT-12) as the recommended alternative and would involve mixing surficial soils into underlying soils as a means of decreasing the copper concentration to below the RAC without soil removal. The major steps in this alternative for a typical residential property are:

1. Sample soils from selected locations on the property and analyze to determine copper concentration, both laterally and with depth. As part of this sampling, the depth of mixable soil (i.e., above the caliche layer) would also be determined.
2. Remove and store personal items within the affected areas of the residential yard.
3. If necessary, remove sod or other vegetation on the affected ground surface.
4. Thoroughly mix the soil using a rototiller or similar piece of equipment to a depth of approximately 6 inches.

6. Verify that the resulting soil mixture is below the action level by sampling on the initial grid and analysis.
7. Where applicable, place sod, seeding, or otherwise revegetate the remediated area.
8. Replace the resident's personal property.

6.0 ANALYSIS OF ALTERNATIVES

The remediation alternatives developed in the previous chapter are evaluated in this chapter. A final remediation alternative is recommended at the end of this evaluation.

6.1 Evaluation Criteria

For evaluating alternatives, the AOC incorporates the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) requirements as embodied in nine evaluation criteria (40 CFR 300.430(e)(9)):

- Overall protection of human health and the environment;
- Compliance with Applicable Standards;
- Long-term effectiveness and permanence;
- Reduction of toxicity, mobility and volume through treatment;
- Short-term effectiveness;
- Implementability;
- Cost;
- State acceptance; and
- Community acceptance.

The first two criteria are termed "threshold" criteria. Threshold criteria are minimum requirements that must be satisfied by an alternative. These criteria are applied to individual alternatives, but not used in the comparative evaluation of alternatives. The next five are the "balancing" criteria. Comparative evaluation is based on the balancing criteria used to assess tradeoffs between alternatives.

The remaining two criteria, state and community acceptance, are "modifying" criteria and are more difficult to assess at the FS stage. Typically, after the FS is finalized, an alternative is selected as the proposed remedial action. The proposed remedial action is described along with the basis for its selection in a Proposed Plan. The evaluation of the modifying criteria is based on state and public comments on the FS and the Proposed Plan. State and community concerns, and any resulting changes in the selected remedial actions, are documented in the Record of Decision (ROD) for the site. Therefore, the two modifying criteria are not evaluated in this document.

The FS criteria are defined below. These definitions are consistent with those in CERCLA and have been developed to minimize overlap of considerations. This allows a more independent evaluation of each criterion, and avoids double counting in the evaluation (i.e., considering the same technical factor more than once).

6.1.1 Threshold Criteria

Under CERCLA, remediation alternatives must meet the following two threshold requirements:

- Overall protection of human health and the environment; and
- Compliance with Applicable Standards.

6.1.1.1 Overall Protection of Human Health and the Environment

This criterion addresses the degree to which the alternative is protective of human health and the environment, considering both long-term and short-term risks. Overall protectiveness is a "threshold" criterion, in that alternatives that do not achieve adequate protection of human health or the environment are eliminated from further consideration. The ability of the alternatives to achieve remedial action objectives is part of the evaluation of this criterion (as well as part of long-term effectiveness).

This criterion considers the evaluation of other criteria, especially long-term effectiveness and permanence, reduction of toxicity, and short-term effectiveness. It is not an independent criterion, but rather a summary of the overall evaluation of these other criteria. Because of this overlap, it is evaluated for screening individual alternatives but not used in comparative evaluation of the alternatives.

6.1.1.2 Compliance with Applicable Standards

This criterion addresses whether or not the alternative meets Applicable Standards, as defined in Chapter 3. As with overall protectiveness, compliance with Applicable Standards is a threshold criterion that must be met for an alternative to be selected.

6.1.2 Balancing Criteria

6.1.2.1 Long-term Effectiveness and Permanence

This criterion addresses (a) risks remaining at the site after implementation of the remediation alternative has been completed, and (b) the reliability of the alternative at reducing risks over an extended period of time. Long-term effectiveness involves estimating the residual risk associated with each alternative relative to the baseline risk, and can be measured in part by the degree to which RAOs are met. Permanence involves estimating the longevity of the remedy (e.g., the lifespan of geosynthetic materials) and the chances of remedy failure.

Risks during the implementation period are addressed under short-term effectiveness. For alternatives which involve operation, maintenance, and/or monitoring for an extended or indefinite time period after completion of construction, associated risks are considered under long-term effectiveness.

6.1.2.2 Reduction of Toxicity, Mobility and Volume through Treatment

This criterion addresses the degree to which a remediation alternative reduces the toxicity of contaminants (e.g., via destruction or detoxification), the ability of contaminants to migrate into the accessible environment, or the quantity of contaminated material. This criterion expresses the preference for treatment under CERCLA. Effectiveness and reliability of treatment are addressed under long-term effectiveness and permanence, and are not addressed under this criterion.

6.1.2.3 Short-term Effectiveness

This criterion addresses short-term effects on human health and the environment while the alternative is being implemented. The evaluation includes consideration of the following factors:

- Health and safety risks to site workers during remedial activities;
- Risk to the community;
- Risk to the environment (short-term ecological risk); and,
- The time required before remedial action objectives are achieved.

6.1.2.4 Implementability

This criterion addresses the degree of difficulty in implementing each alternative. Implementability can be subdivided into technical feasibility, administrative feasibility, and availability of services and materials. Implementability issues become more significant as the complexity of the alternative increases and as the reliance on innovative technology increases. Implementability issues are important because they address the potential for delays, cost overruns, and failure to implement the remedy in a way that achieves the intended results.

Known implementation requirements with quantifiable cost impacts (e.g., need for personal protective gear and associated loss of productivity) are included in the cost estimates. The implementability criterion under discussion here focuses on the more uncertain potential difficulties in completing the remedial action. It is evaluated considering the following:

- **Technical Feasibility**. Technical feasibility addresses the site-specific factors that could prevent successful use of an alternative, such as physical interferences or constraints, practical limitations of an alternative, unexpected soil properties, and the like. The evaluation includes the likelihood of delays due to technical problems and the ease of modifying the alternative, if required.
- **Administrative Feasibility**. The degree of difficulty anticipated due to regulatory constraints, the ability to obtain permits and approvals, and the degree of coordination required between various agencies and stakeholder groups.
- **Availability of Services and Materials**. The availability of experienced contractors and personnel, equipment, materials, suitable disposal facilities, and other services and materials needed to implement the alternative.

6.1.2.5 Cost

This criterion is used to consider the costs of implementing each alternative, including capital, operating and maintenance, and monitoring costs. Costs that are excessive compared to the overall effectiveness may be considered as one of several factors used to eliminate alternatives. Alternatives providing effectiveness and implementability similar to that of another alternative, but at greater cost, may also be eliminated.

For this FS, maintenance and monitoring costs are compared on a net present value basis. The interest rate of 5% (net of inflation) used for present value calculations is the rate recommended by the EPA for feasibility study cost estimates, and is in the range of typical historical net interest rates.

The cost estimates in this FS are based on the description of the alternatives and associated design assumptions in Chapter 4. The design assumptions used here are based on site knowledge from the RI and other studies, and are sufficient for the purposes of comparative evaluation of the alternatives; however, they are not necessarily the same as those that would be used for the final, detailed design.

For cost estimates, EPA guidance suggests a target accuracy of +50% to -30%. The cost estimates in the FS were developed to meet this target to the extent practical. However, the focus of the FS cost estimating is on determining relative costs, and consequently, these estimates should not be used for budgeting purposes. Although an attempt was made to include all significant cost items, some costs common to all alternatives might not have been included. Significant changes in design assumptions, although not anticipated, could result in costs outside the target accuracy range.

6.1.2.6 State and Community Acceptance

The last two evaluation criteria are not evaluated in the Hurley FS. These criteria will be addressed in the Record of Decision.

6.2 Detailed Evaluation of Alternatives

In this section, a detailed analysis of each of the alternatives is performed against the evaluation criteria. Section 6.3 provides a comparison of the alternatives using the criteria.

6.2.1 <u>Alternative A – No Action</u>

6.2.1.1 Overall Protection of Human Health and the Environment

Alternative A does not provide any form of overall protection of human health and the environment and does not address any of the RAOs.

6.2.1.2 Compliance with Applicable Standards

Alternative A is not compliant with the Applicable Standards discussed in Chapter 3.

6.2.1.3 Long-Term Effectiveness and Permanence

Alternative A is not effective in the long-term or permanent.

6.2.1.4 Reduction in Toxicity, Mobility and Volume through Treatment

Alternative A does not reduce the toxicity, mobility, or volume.

6.2.1.5 Short-Term Effectiveness

Alternative A is effective in the short-term.

6.2.1.6 Implementability

Alternative A would be the easiest to implement, because no action is required.

6.2.1.7 Cost

There are no costs associated with Alternative A.

6.2.2 Alternative B – Institutional Controls

This alternative consists of land use restrictions (AT-02), public education (AT-03), and site monitoring (AT-04).

6.2.2.1 Overall Protection of Human Health and the Environment

The ability of Alternative B to satisfy this criterion is low.

6.2.2.2 Compliance with Applicable Standards

Alternative B may comply with the Applicable Standards in limited situations or for limited time periods, but the likelihood of full compliance on an ongoing basis is low.

6.2.2.3 Long-Term Effectiveness and Permanence

The effectiveness of attempting to prevent normal residential use of residential property is unlikely, particularly given the exposure pathway (incidental ingestion of soil by children playing in the yard) used to develop the RAC. Even if institutional controls could be successfully implemented, they would be effective only as long as the social institutions exist to continue the implementation, and higher priorities do not override land use restrictions in the future; and thus they cannot be considered permanent.

6.2.2.4 Reduction in Toxicity, Mobility and Volume through Treatment

Alternative B does not reduce the toxicity, mobility, or volume.

6.2.2.5 Short-Term Effectiveness

Alternative B would be moderately effective in the short-term.

6.2.2.6 Implementability

Alternative B requires only administrative and educational activities. While these in themselves could be readily implemented, a potentially far greater impact is the reluctance of property owners to accept deed restrictions which would lower the value and liquidity of their property. On this basis, the implementability of Alternative B is considered low.

6.2.2.7 Cost

The costs associated with Alternative B would be relatively low; it is expected that deed restrictions and education costs could be implemented for $1,000 to $2,000 per property.

6.2.3 Alternative C - Excavation and Reuse and Recycling

This alternative consists of excavation (AT-09) and reuse and recycling (AT-13).

6.2.3.1 Overall Protection of Human Health and the Environment

Completely removing the contaminated soil to a depth where the copper levels in all remaining soil are below the RAC would satisfy all requirements for protecting human health and the environment.

6.2.3.2 Compliance with Applicable Standards

Alternative C is compliant with the applicable standards discussed in Chapter 3.

6.2.3.3 Long-Term Effectiveness and Permanence

Removing all of the contaminated soil results in a completely effective, permanent condition.

6.2.3.4 Reduction in Toxicity, Mobility and Volume through Treatment

All contaminated soil would be removed, thus completely eliminating the toxicity, mobility, and volume of contaminant. However, Alternative C does not reduce the toxicity, mobility, or volume by any form of treatment.

6.2.3.5 Short-Term Effectiveness

Risks to workers associated with Alternative C include the normal industrial risks associated with soil excavation and transport. Risks to the community involve:

- Nuisance dust – Although dust control would be a significant requirement of this alternative, some off-site dust might be experienced during periods of hot, dry weather. Such dust is not expected to contain sufficient levels of contaminants or persist for long enough to cause a health hazard, but may be irritating.
- Noise – Equipment used for remedial activities would be required to comply with OSHA and other applicable standards, and hours of operation would be limited. Therefore, although noise at nuisance levels could be experienced by residents during remediation, it is unlikely to have health effects.
- Increased chance of traffic accidents – Traffic will increase due to trucks transporting construction materials and equipment and the personal vehicles of construction workers. Limiting construction activity to daylight hours and providing traffic control would mitigate some of this risk.
- Injury to intruders – Access to laydown yards, the remediation site, and other affected areas would be controlled, which would essentially eliminate the potential for inadvertent intrusion, as well as discouraging deliberate intrusion.

On this basis, the short-term effectiveness of Alternative C is considered moderate.

6.2.3.6 Implementability

RI data indicate that soils with copper concentrations above the action level are largely confined to the upper few inches of the existing ground. Removal of this amount of soil would not be expected to cause problems with damage to underground utilities or stability of building foundations. However, excavation depths greater than about 1 foot would probably be more difficult to implement.

Although residential obstructions (houses, fences, etc.) would limit the size of excavation equipment that could be used, and potentially require a significant amount of hand excavation, these methods are well established and should pose no unusual difficulties.

Because Alternative C is highly effective in addressing the RAOs and Applicable Standards, the administrative feasibility is considered high.

Alternative C does not require personnel skills, specialized equipment, or unusual materials beyond those normally used for relatively simple earthworks construction. This level of service and materials should be readily available in the Hurley / Silver City area.

6.2.3.7 Cost

Costs for this alternative were estimated on the basis of costs for complete removal and restoration at four residential properties during the Pilot Program (as described in Section 2.6.5) conducted during July and August of 2005. These costs are summarized in Appendix A. The Pilot Program properties are considered representative of the range of conditions that would be encountered during remediation of the entire HSIU. The cost for soil removal and yard restoration activities under Alternative C is expected to be in the range of \$15,000 to \$20,000 per property, with an additional \$7,600 per property for sampling and analysis, quality assurance, and construction oversight activities. The total cost per property for this Alternative is therefore estimated to be in the range of \$22,500 to \$27,500.

Option - reuse w/

6.2.4 Alternative D – Excavation and Containment

This alternative consists of excavation (AT-09) and soil cover (AT-05).

6.2.4.1 Overall Protection of Human Health and the Environment

Placing a soil cover over the remaining contaminated soil would eliminate direct human contact and the ingestion pathway and eliminate its potential release into the environment if the integrity of the cover is maintained. If the cover were breached, by digging, construction, or similar disruptive activities, contaminated soil could reach the surface in local areas. Whether this would pose a health risk would depend on the extent, location, and degree of contamination.

6.2.4.2 Compliance with Applicable Standards

Alternative D is compliant with the applicable standards discussed in Chapter 3 of this report.

6.2.4.3 Long-Term Effectiveness and Permanence

A soil cover may be limited as a long-term or permanent solution. Over time, the soil cover could erode, be disturbed by the property owners, or otherwise be compromised. The geotextile marker layer will deteriorate; lifetimes are estimated to be several tens to a few hundreds of years. For these reasons, Alternative D is considered only moderately effective and permanent in the long-term.

6.2.4.4 Reduction in Toxicity, Mobility and Volume through Treatment

The toxicity of the remaining contaminants would not be decreased by the addition of a soil cover. Upward migration of copper compounds has not been observed at the HSIU and is not considered a realistic mechanism at this site. The quantity of contaminated material would be reduced but not eliminated under this Alternative. However, Alternative D does not reduce the toxicity, mobility, or volume by any form of treatment.

6.2.4.5 Short-Term Effectiveness

Because the remediation activities and materials are essentially the same as those for Alternative C, the short term effectiveness is considered the same as for Alternative C.

6.2.4.6 Implementability

The implementability of Alternative D is very similar to that of Alternative C, except that the lower degree of protection and restrictions on activities by the property owner could significantly reduce the administrative feasibility. For this reason, the overall implementability of Alternative D is considered moderate.

6.2.4.7 Cost

Capital costs for this alternative are essentially the same as those for Alternative C, with the addition of costs related to the geotextile marker layer, which are expected to be less than $1,000 per property. In addition, this alternative would require ongoing monitoring and periodic maintenance for an assumed period of 30 years. For FS purposes, monitoring is assumed to occur yearly for the first 5 years, every other year for the next 10 years, and every 5 years for the remainder of the monitoring period. Maintenance is assumed to be performed every 5 years. The present value analysis of these activities is shown in Appendix A, and adds about an additional $7,600 cost to each property.

The total cost per property for Alternative D is estimated to be in the range of $30,500 to $35,500.

6.2.5 Alternative E – In-Situ and Ex-Situ Treatment — MIXING

This alternative consists of soil tilling (AT-12)

6.2.5.1 Overall Protection of Human Health and the Environment

Mixing contaminated soils with less contaminated or uncontaminated soils would effectively decrease the copper concentration in the soil to below the action level, thus addressing the RAOs. Alternative E would satisfy all requirements for protecting human health and the environment.

6.2.5.2 Compliance with Applicable Standards

Alternative E would comply with the applicable standards discussed in Chapter 3.

6.2.5.3 Long-Term Effectiveness and Permanence

The RI found that the COCs are concentrated in the near-surface soil, particularly the top one to three inches. Using these data, the average copper concentration that would result from tilling was calculated by averaging the concentrations at each sample location over depths up to 6 inches. The results are shown on Figure 6-1 and indicate that tilling of soils with surficial copper concentrations of up to 8,000 mg/kg would reduce the average concentration to below the action level of 5,000 mg/kg.

The effectiveness of tilling was tested as part of the Pilot Program (Section 2.6.5). This field test was conducted to test efficacy of tilling, however, it was not documented because preparations were already underway to conduct the Hurley IRA with the preferred alternative of excavation and reuse.

A test area of soil was sampled and analyzed for copper at the surface, at 3 inches, and at 6 inches depth prior to tilling. The concentrations of the co-located depths were averaged to predict the mixed copper concentration. After the area was tilled, the mixed soil was sampled and analyzed at the surface. The mixed soil copper concentration was reduced to below the RAC as predicted by the average concentrations in the test area.

Mixing the soil to achieve copper concentrations below the action level is a permanent solution that would be immediately effective. It was demonstrated that mixing of soil containing concentrations of copper up to 8,000 mg/kg with 6 inches of underlying soil was effective in reducing soil copper concentrations to below the RAC. This method should also be effective for soil with concentrations greater than 8,000 mg/kg if mixed with proportionally more soil from a greater depth.

6.2.5.4 Reduction in Toxicity, Mobility and Volume through Treatment

Mixing the soil reduces the level of contamination, and because of the amount of calcium carbonate in the soil, reduces the toxicity and mobility of copper in the soil. This method does not decrease the volume of contaminated soil.

6.2.5.5 Short-Term Effectiveness

The short term effectiveness of Alternative E is similar to that of Alternative C. However, the risks associated with traffic accidents are reduced because there would be no transport of contaminated soil or import of clean soil. In addition, the time required to implement Alternative E on a given property would probably be less than for other alternatives, thereby reducing the duration of other short-term effects.

On this basis, the short-term effectiveness of Alternative E is considered moderately high.

6.2.5.6 Implementability

The volume of readily usable underlying soil available for mixing would be limited by the shallow caliche layer found throughout the site. This layer generally occurs between three and six inches below grade, and consists of a carbonate precipitate that would present difficulties for tilling due to its high strength and density. Consequently, tilling would only be implementable in locations where the caliche layer is not too shallow.

It is envisioned that tilling would be accomplished using conventional equipment such as heavy-duty garden rototillers. This method was tested as part of the Pilot Program, as described in Section 2.6.5, which indicated that several passes are required to produce a relatively uniform soil mixture. The test showed that a shallow caliche layer can present difficulties in operating the type of tilling equipment used for this test, and can limit the cutting depth of the tiller.

For the tilling alternative, the remediation contractor would need to test various methods, equipment, and other operational details prior to determining the implementability of this alternative in the field. Some foreseeable operational details include adverse impacts of soil moisture on mixing results, optimum equipment speed and tilling depth, effects of shallow caliche, and other factors.

For these reasons, the implementability of Alternative E is considered moderate.

6.2.5.7 Cost

The remedial construction costs for Alternative E would be significantly less than those for Alternative C, because there is no soil removal, transport, or replacement. Although the detailed procedures for Alternative E have not been developed, experience during the Pilot Program (Section 2.6.5) suggests that it is not unreasonable to assume that construction costs would be about 60% to 70% of those for Alternative C, or about $10,000 to $15,000 per property. However, the costs for sampling and analysis, quality assurance, and construction oversight activities would be essentially the same as for Alternative C at about $7,600 per property. The total cost per property for Alternative E is therefore estimated to be in the range of $17,500 to $22,500.

6.3 Comparative Analysis of Alternatives

The five alternatives are evaluated against the balancing criteria in Table 6-1. The cost criterion is scored opposite the other alternatives so that a high score is desirable, consistent with the other criteria.

Evaluation numbers from 1 to 5 are assigned to each criterion to represent the ability of each alternative to be achieved, with 5 being the most favorable evaluation. These numbers are based on the preceding discussions and represent relative assessments based on engineering judgment and experience.

As might be expected, the evaluation in Table 6-1 indicates that Alternatives A (No Action), and B (Institutional Controls), are not viable alternatives because they are not protective or effective, and would probably not be acceptable to the community. Of the remaining alternatives, Alternatives C (Excavation and Reuse), and E (In-Situ and Ex-Situ Treatment), are effective permanent remedies. Alternative D (Containment), is potentially less effective over the long term and is significantly more expensive relative to Alternatives C and E.

Although lower in cost relative to Alternatives C and D, the implementability of Alternative E (In-Situ and Ex-Situ Treatment), has not been thoroughly tested, and the details of the methodology require development.

On this basis, Alternative C (Excavation and Reuse), is recommended for remediation of residential properties in the Hurley HSIU. This Alternative provides an effective and implementable remedy with the highest level of community acceptance, at a relatively moderate cost. Alternative D (Containment) would be implemented only if there is an over-riding reason why complete removal could not be performed. Because of its economic advantages, Alternative E (In-Situ and Ex-Situ Treatment), could be used in low copper concentration area, but further tests should be performed in the field to verify its implementability and effectiveness, and to develop reliable procedures.

7.0 REFERENCES

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TABLES

TABLE 2-1

Maximum Reference Soil Concentrations
Hurley Soils Investigation Unit

Investigation Constituents	Hurley Maximum Concentration (mg/kg)	North Hurley 95% UCL (mg/kg)	Maximum Reference Soil Concentration (mg/kg)
Arsenic	9	2.98	3.1
Barium	611	192	183
Cadmium	18.1	1.3	0.83
Cobalt	28.2	13.1	18
Copper	26,900	836	216
Iron	NA	NA	80000 [a]
Lead	1,270	128	28
Manganese	3,510	832	686
Molybdenum	114	4.1	<0.6
Selenium	3	<1.1	1.3
Silver	3.5	<1.1	<0.2
Zinc	1,020	309	82

UCL = Upper confidence level

Shaded areas indicate exceedance of maximum refierence concentration.

[a] Not evaluated as part of the Hurley Soils IU, taken from Hanover/Whitewater Creek IU background data.

TABLE 2-2

Phases of the HSIU Remedial Investigation

Phase	Citation	Report Date	Purpose
AOC Background Report	Chino 1995	August 20, 1995	Initial report of existing data for the AOC Investigation Area
Remedial Investigation Proposal	Chino 1995	October 14, 1995	Work plan for conducting Remedial Investigation
Phase I Remedial Investigation Report	Chino 1998	November 10, 1998	Residential soil characterization Garden soil characterization Surface water and sediment characterization Subsurface soil characterization Ambient air characterization Supplemental sampling Confirmation soil sampling Air filter reanalysis
Phase II Remedial Investigation Proposal	Chino 1999	April 30, 1999	Work plans for additional characterizations in Hurley
Human Health Risk Assessment Volumes I and II	Gradient 2000	February 22, 2000	Human health risk assessment
Phase II Remedial Investigation Report	Chino 2000	March 27, 2000	Lead source characterization Isopleth refinement Depth to caliche Alleyway characterization Native versus non-native soil mapping XRF calibration
Hurley Homegrown Garden Vegetable Study	Chino 2001	August 31, 2001	Study of metals uptake in homegrown garden plants
Bioaccessibility Study for the Hurley Soils Investigation Unit	Chino 2002	April 25, 2002	Study of copper solubility and speciation to determine bioaccessibility in humans
Addendum to the Human Health Risk Assessment for Hurley Soils Investigation Unit	Gradient 2003	December 19, 2003	Revised portions of the human health risk assessment to be used as the basis for a Remedial Action Criterion for copper in soil
Program Work Plan, Interim Remedial Action, Hurley Soil Investigation Unit	Chino 2005	June 23, 2005	Work plan for an interim remedial action pilot program in Hurley
Work Plan for the Hurley Interim Remedial Action at the Hurley Soils Investigation Unit	Chino 2006	April 7, 2006	Work plan for the Hurley interim remedial action
Completion Report for the Interim Remedial Action at the Hurley Soils Investigation Unit	Chino 2008	January 24, 2008	Summary report for the Hurley interim remedial action

Evaluation of Decision Criteria for the Hurley Soils Investigation Unit
Surface Soil Ingestion Pathway

Investigative Constituent	**Hurley (maximum concentration) (mg/kg)**	**North Hurley (95% UCL) (mg/kg)**	**Decision Criteria (mg/kg)**	**EPA Region VI Human-Health Medium-Specific Screening Criteria (mg/kg)[2]**	**Criteria Exceeded in Hurley**	**Criteria Exceeded in North Hurley**
Arsenic (Cancer Endpoint)	9	2.98	0.43	0.39	Yes	Yes
Arsenic (Non-Cancer Endpoint)	9	2.98	0.43	22	No	No
Barium	611	192	5,500	16,000	No	No
Cadmium	18.1	1.3	39	39	No	No
Cobalt	28.2	13.1	4,700	900	No	No
Copper	26,900	836	3,100	2,900	Yes	No
Lead	1,270	128	400	400	Yes	No
Manganese	3,510	832	1,800	3,200	Yes	No
Molybdenum	114	4.1	390	390	No	No
Selenium	3	<1.1	390	390	No	No
Silver	3.5	<1.1	390	390	No	No
Zinc	1,020	309	23,000	23,000	No	No

Note: UCL = Upper confidence limit on the mean. This value was used as a conservative estimate of the mean.

[1] **Source:** EPA (1995) Region III Risk-Based Screening Levels.

[2] **Source:** EPA (2006) Region VI Human Health, Medium-Specific Screening Levels.

TABLE 4-1

Screening of General Response Actions

General Response Actions (GRA)	GRA Number	Associated Technologies (AT)	AT Number	Description	Screening Comments
No action	GRA-01	None	AT-01	No action. Leave the site in its current state.	Retained, for baseline comparison
Institutional Controls	GRA-02	Land Use Restrictions	AT-02	Zoning or deed restrictions	Retained
		Public Education	AT-03	Presentations and/or mailings explaining the remedy prior to and during implementation of a remedial action.	
Monitoring	GRA-03	Site Monitoring	AT-04	Short- and long-term site monitoring to ensure that potential risks to human health and the environment are controlled while the selected remedy is being implemented and to provide quality control	Retained, ancillary to primary remediation technologies
Containment	GRA-04	Soil Cover	AT-05	Placement of a minimum thickness of 6 inches of clean soil cover over copper-contaminated soil	Retained
		Pavement Cover	AT-06	Asphalt and/or concrete pavement over existing soils	Rejected
		Dust Controls	AT-07	Stabilizing surface soils to minimize wind dispersion of affected soils	Rejected
		Surface Water Controls	AT-08	Preventing surface water run-on to the affected area and run-off from the affected area	Retained, ancillary to primary remediation technologies

Screening of General Response Actions

General Response Actions (GRA)	GRA Number	Associated Technologies (AT)	AT Number	Description	Screening Comments
Excavation and Disposal	GRA-05	Excavation	AT-09	Complete or partial excavation to remove soils with copper above the action level from residential yards.	Retained
		Disposal	AT-10	Dispose of excavated soils at existing Chino stockpiles or commercial landfills	Retained, only for non-contaminated waste
In-Situ and Ex-Situ Treatment	GRA-06	Chemical Amendment	AT-11	Addition of a chemical amendment to reduce the mobility of the COCs	Rejected
		Soil Tilling	AT-12	Mixing of surficial soils into underlying soils as a means of decreasing the copper concentration to below the RAC	Retained
Reuse and Recycling	GRA-07	Reuse and Recycling	AT-13	Placement of excavated soil on existing Chino tailings piles that are proposed for recycling	Retained

Copper Species in Hurley Soils

Individual Particles		Sample ID / Location	Relative Copper Mass												
		Sample ID	U05-0650	U05-0651	U05-0652	U05-0653	U05-0654	U05-0655	U05-0656	U05-0657	U05-0658	U05-0659	U05-0660	U05-0661	
		Location	G-46	G-50	G-50	P2-02	P2-01	G-32	G-32	P2-03	P2-03	G-30	G-24	G-21	Averages
Mineral ID	**Common Names**	**Category**													
CuFe2S3	Cubanite	Low	12.1%	0%	3.1%	24%	0%	37%	4.8%	16%	2.4%	4.0%	8.3%	20%	11%
CuFeS2	Chalcopyrite	Low	21.1%	24.2%	7.4%	10.7%	35.2%	8.6%	22%	13%	24%	16%	50%	4.9%	20%
CuS	Covellite	Low	27.4%	37.1%	13.2%	18%	1.56%	10.9%	16%	20%	20%	19%	2.8%	15%	16%
Cu5FeS4	Bornite	Low	14.0%	16.8%	11.9%	18%	16.7%	15.4%	22%	12.6%	6.6%	3.0%	1.5%	17%	13%
Cu2FeS2	Cu2FeS2	Low	0%	0%	0%	0%	0%	0%	0%	0%	10.3%	0%	0%	0%	0.93%
Cu2S	Chalcocite	Low	0%	0%	0%	3.9%	9.9%	0.71%	0%	0%	0%	4.9%	0%	3.4%	2.1%
Cu3Fe4S7	Cu3Fe4S7	Low	0%	0%	0%	0%	0%	0%	1.1%	0%	0%	0%	0%	0%	0.10%
Cu	Native Copper	Intermediate	5.3%	0%	55%	10.5%	12.5%	0.87%	0%	0%	8.4%	0%	1.2%	12%	9.1%
CuO	Tenorite	Intermediate	12.7%	15.5%	6.6%	5.5%	9.2%	10.2%	13.2%	15%	15%	47%	19%	14%	16%
FeCuO	FeCuO	Intermediate	3.2%	2.6%	0.72%	2.2%	4.7%	11.0%	8.9%	4.0%	5.6%	2.8%	8.3%	5.1%	5.1%
CuSO4	Copper sulfate	High	1.5%	2.2%	1.0%	3.8%	5.5%	1.7%	2.7%	11.6%	2.2%	0%	4.4%	1.8%	3.3%
FeSO4	FeSO4	High	0.51%	0.038%	0.15%	0.37%	1.8%	1.7%	3.1%	2.5%	2.1%	1.2%	1.6%	1.0%	1.4%
FeOOH	Goethite	High	1.6%	1.6%	0.57%	2.0%	3.1%	1.8%	3.3%	1.9%	2.5%	1.3%	2.7%	5.7%	2.4%
Cu2Cl(OH)	Cu2Cl(OH)	Other	0%	0%	0%	0.40%	0%	0%	0%	0%	0%	0%	0%	0%	0.036%
CaCO3/Clay	CaCO3/Clay	Other	0.15%	0%	0%	0%	0%	0.017%	0.85%	2.0%	0.50%	0%	0%	0%	0.30%
FeSiO4	FeSiO4	Other	0.016%	0%	0%	0.090%	0%	0.13%	0.082%	0.31%	0.37%	0%	0%	0.086%	0.10%
MnOOH	MnOOH	Other	0%	0%	0.010%	0%	0%	0%	0%	0%	0.032%	0%	0.069%	0%	0.010%
Phosphate	Phosphate	Other	0%	0%	0%	0%	0%	0.38%	2.5%	0.0%	0%	0%	0%	0%	0.26%
Pyrite	Pyrite	Other	0.011%	0%	0%	0%	0%	0.017%	0.012%	0.019%	0.0089%	0.013%	0%	0.023%	0.008%
Slag	Slag	Other	0%	0%	0%	0%	0%	0%	0.014%	0%	0%	0%	0%	0%	0.0%
SnCu	SnCu	Other	0.39%	0%	0.59%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0.054%
Total			**100.00%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**
Solubility Category															
Sulfides		Low	75%	78%	36%	75%	63%	72%	65%	62%	63%	47%	63%	60%	62%
Oxides/Native Copper		Intermediate	21%	18%	62%	18%	26%	22%	22%	19%	29%	50%	28%	31%	30%
Sulfates/Iron Oxides		High	3.6%	3.8%	1.7%	6.1%	10%	5.1%	9.1%	16%	6.7%	2.5%	8.7%	8.5%	7.2%
Miscellaneous		Other	0.57%	0.0%	0.61%	0.49%	0.0%	0.55%	3.4%	2.3%	0.92%	0.013%	0.07%	0.11%	0.77%
Total			**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

Screening of Remediation Alternatives

Remedial Action General Response Actions	Associated Technologies (AT)	AT Number	Options	Description	Screening Comments
Alternative A - No action	None	AT-01	Not applicable	No action. Leave the site in its current state.	Not viable alternative
Alternative B - Institutional Controls	Land Use Restrictions	AT-02	Access restrictions	Zoning or deed restrictions	Not viable alternatives
	Public Education	AT-03	Presentations and/or mailings	Explanation of the remedy prior to and during implementation of a remedial action.	
	Monitoring	AT-04	Site Monitoring	Short- and long-term site monitoring to ensure that potential risks to human health and the environment are controlled while the selected remedy is being implemented and to provide quality control	
Alternative C - Excavation and Reuse	Excavation	AT-09	Complete Removal	Removal of soils with copper above the action level from residential yards	Recommended for remediation of residential properties in the Hurley HSIU.
	Reuse and Recycling	AT-13	Recycling	Excavated soil is placed on existing Chino tailings piles that are proposed for recycling	
Alternative D - Containment	Excavation	AT-09	Partial Removal	In areas where remaining soil is still above the action level, place a geotextile fabric on the excavated surface prior to backfilling.	Implemented only if there is an over-riding reason why complete removal could not be performed.
	Soil Cover	AT-05	Soil Cover	Placement of a minimum thickness of 6 inches of clean soil over the geotextile	
Alternative E - In-Situ Treatment	Soil Tilling	AT-12	Soil Tilling	Mixing of surficial soils into underlying soils as a means of decreasing the copper concentration to below the RAC	Should be considered for properties in the transition zone at the boundary of the remediation area.[1]

[1]Further tests should be performed in the field to verify its implementability and effectiveness, and to develop reliable procedures.

Comparison of Alternatives

Alternative	Long Term Effectiveness and Permanance	Reduce Toxicity, Mobility, Volume by Treatment	Short-Term Effectiveness	Implementability	Cost [a]	Score
A. No Action	1	1	5	5	5	17
B. Institutional Controls	2	1	5	1	4	13
C. Excavation and Reuse	5	4	3	4	2	18
D. Containment	3	1	3	3	1	11
E. In-Situ and Ex-Situ Treatment	5 [b]	1	4	3	3	11

Ability to Achieve Criterion:
1 = Very low
2 = Moderately low
3 = Moderate
4 = Moderately high
5 = Very high

Cost Criterion [a]:
1 = Very high
2 = Moderately high
3 = Moderate
4 = Moderately low
5 = Very low

[a] Cost is rated opposite the other alternatives in order to be comparable. A low cost alternative is scored high, and a high cost alternative is scored low.

[b] Based on the results shown in Figure 6-1, this criteria is effective only in areas with copper concentrations less than 8,000 mg/kg.

FIGURES

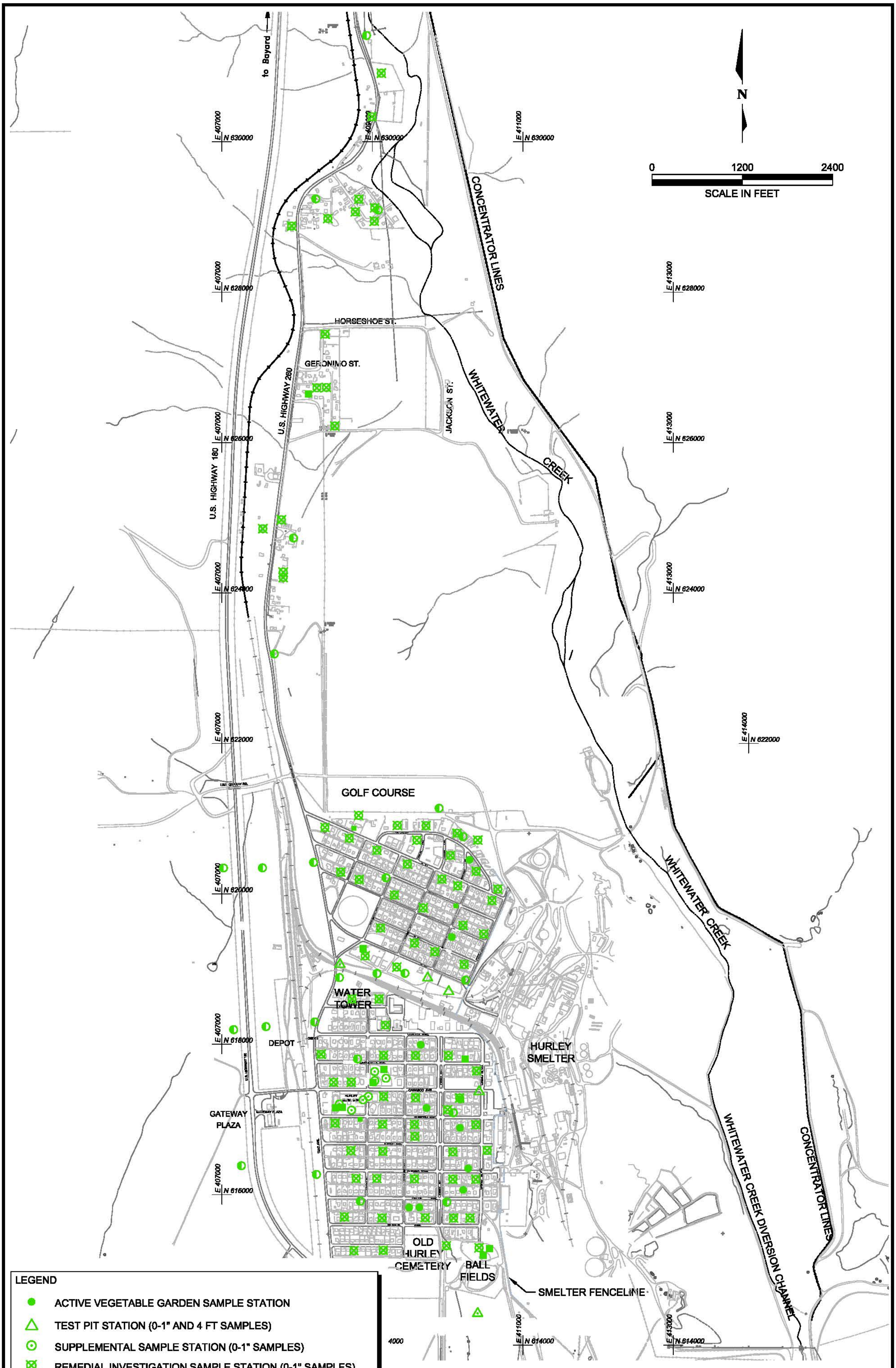
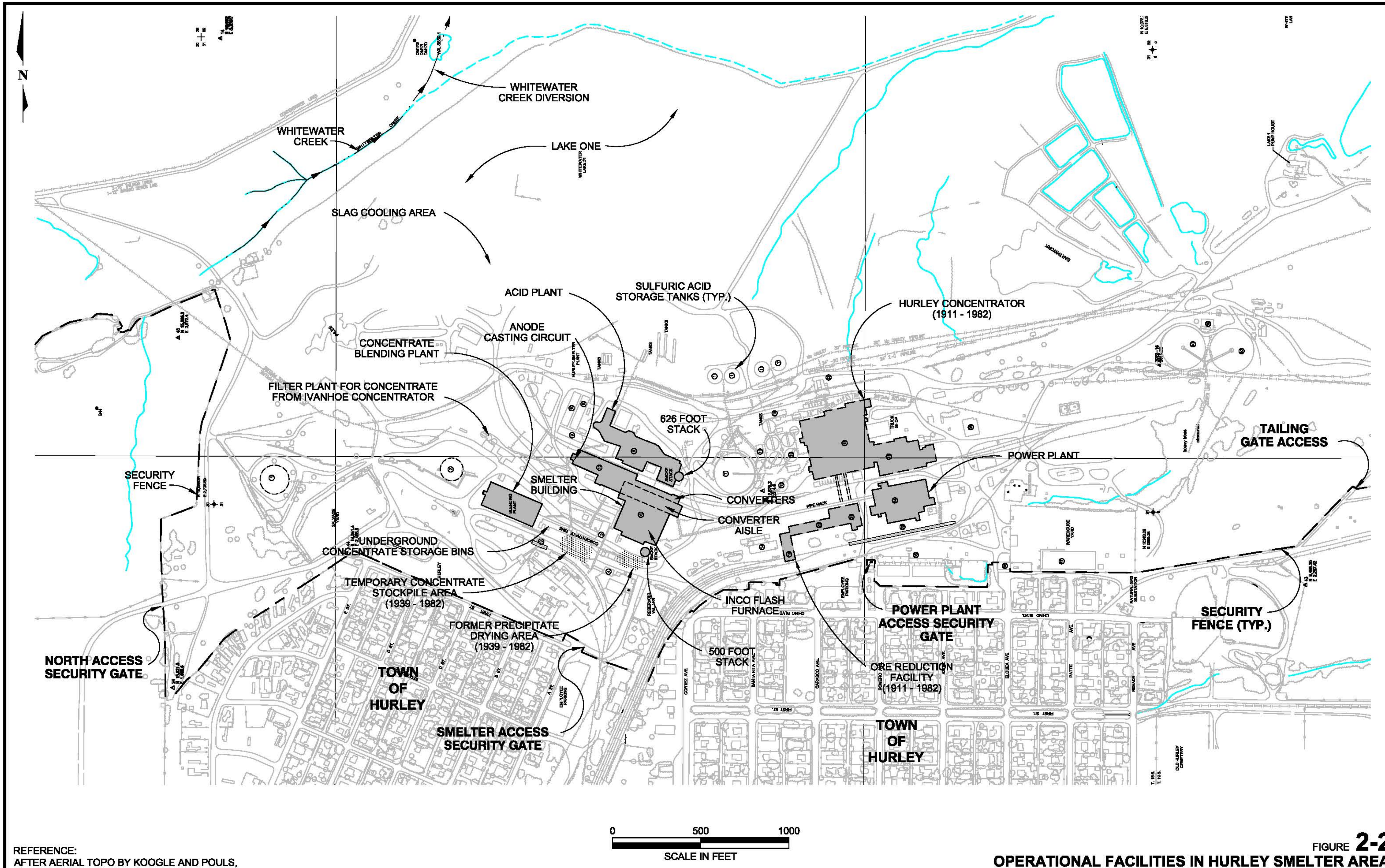


FIGURE **2-1**
HSIU LAYOUT AND SAMPLING LOCATIONS
CHINO/HURLEY FS/NM



REFERENCE:
AFTER AERIAL TOPO BY KOOGLE AND POULS,
DATED: JULY 1991.

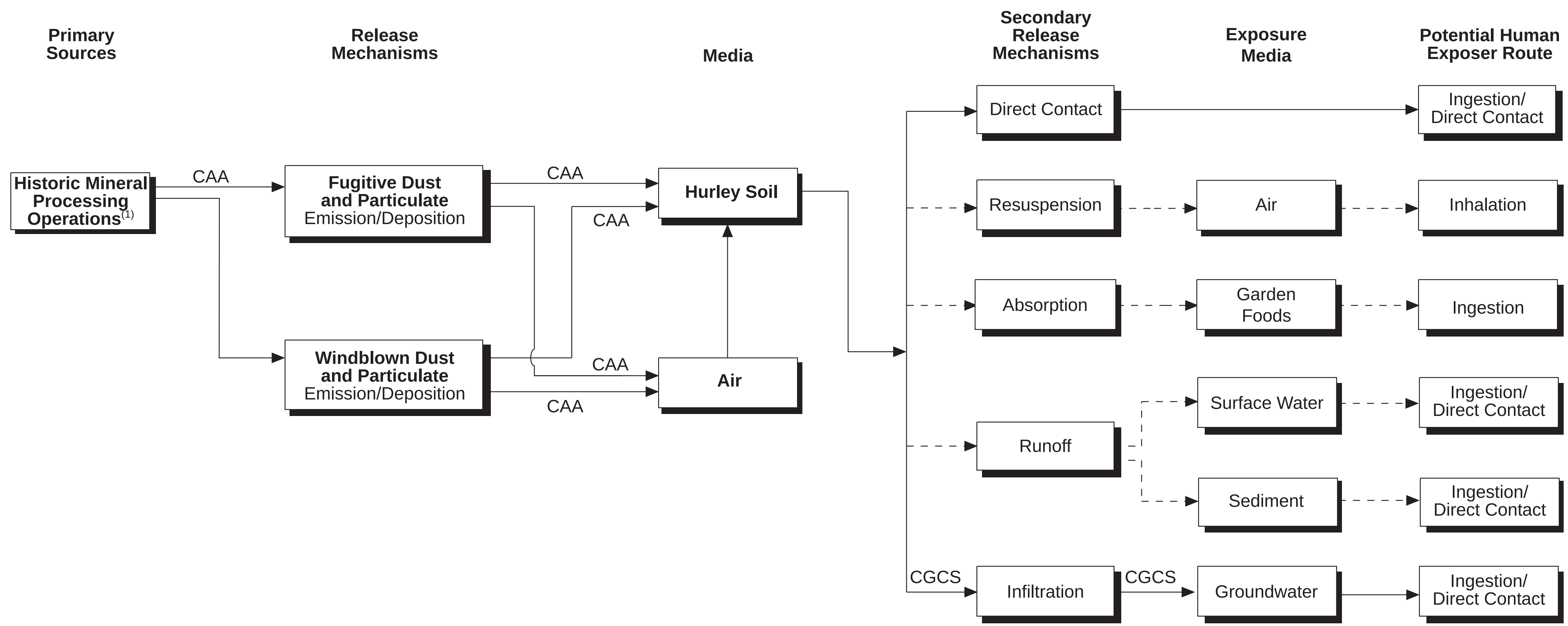
FIGURE **2-2**

OPERATIONAL FACILITIES IN HURLEY SMELTER AREA

CHINO/HURLEY FS/NM

073_92553_11_200_F2-2.dwg | Layout: Layout1 | Modified: 03/12/2008, 13:21 | Plotted: 03/13/2008, 14:43

Golder Associates



NOTES

1. Includes historic mineral processing activities related to operation of the Hurley Mill at the Hurley smelter, including smelter stacks and material handling operations.

2. CAA - Currently addressed under Clean Air Act, not addressed under AOC.

3. CGCS - Currently addressed under compressive groundwater characterization study.

- - - ▶ Complete Pathway

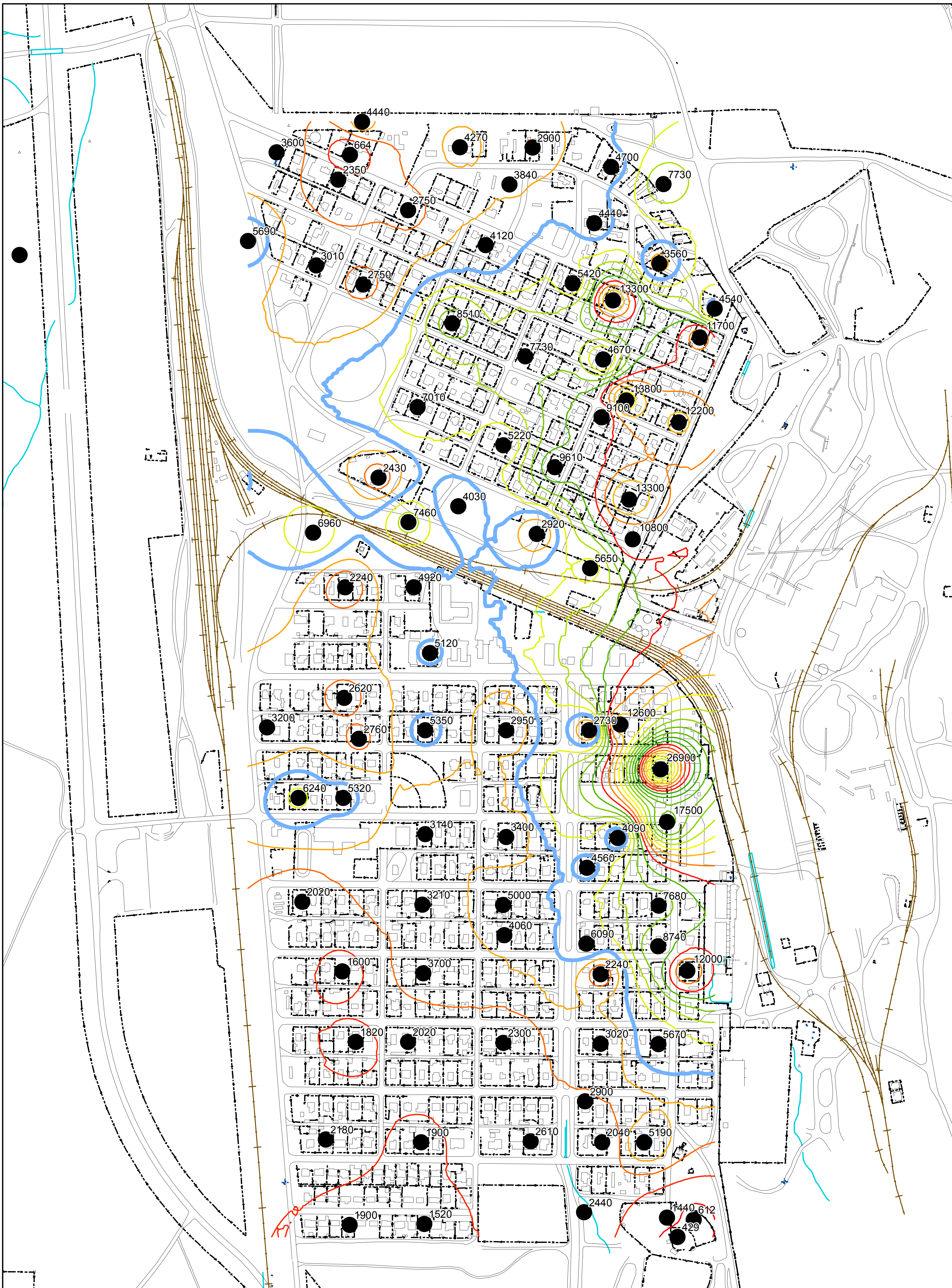
——▶ Incomplete, or exposures below screening levels

FIGURE 3-1

CONCEPTUAL SITE MODEL FOR THE HSIU

CHINO/HURLEY INTERIM REMEDIAL A./NM

Golder Associates



Notes:
- Contour data derived from sample point data using Inverse Distance Weighting Algorithm
- Remedial Action Criterion = 5,000 mg/kg copper

LEGEND

1.0● Sample Location and Copper Concentration (mg/Kg)

Contour of Copper Concentration (5,000 mg/Kg)

Railroads

Roadways

Utilities

Hydrology

0 500
Scale in Feet

N

Map Projection: New Mexico State Plan, NAD83, West, Feet

Source:
Chino Mines, RGIS

This figure was originally produced in color. Reproduction in black and white may result in a loss of information.

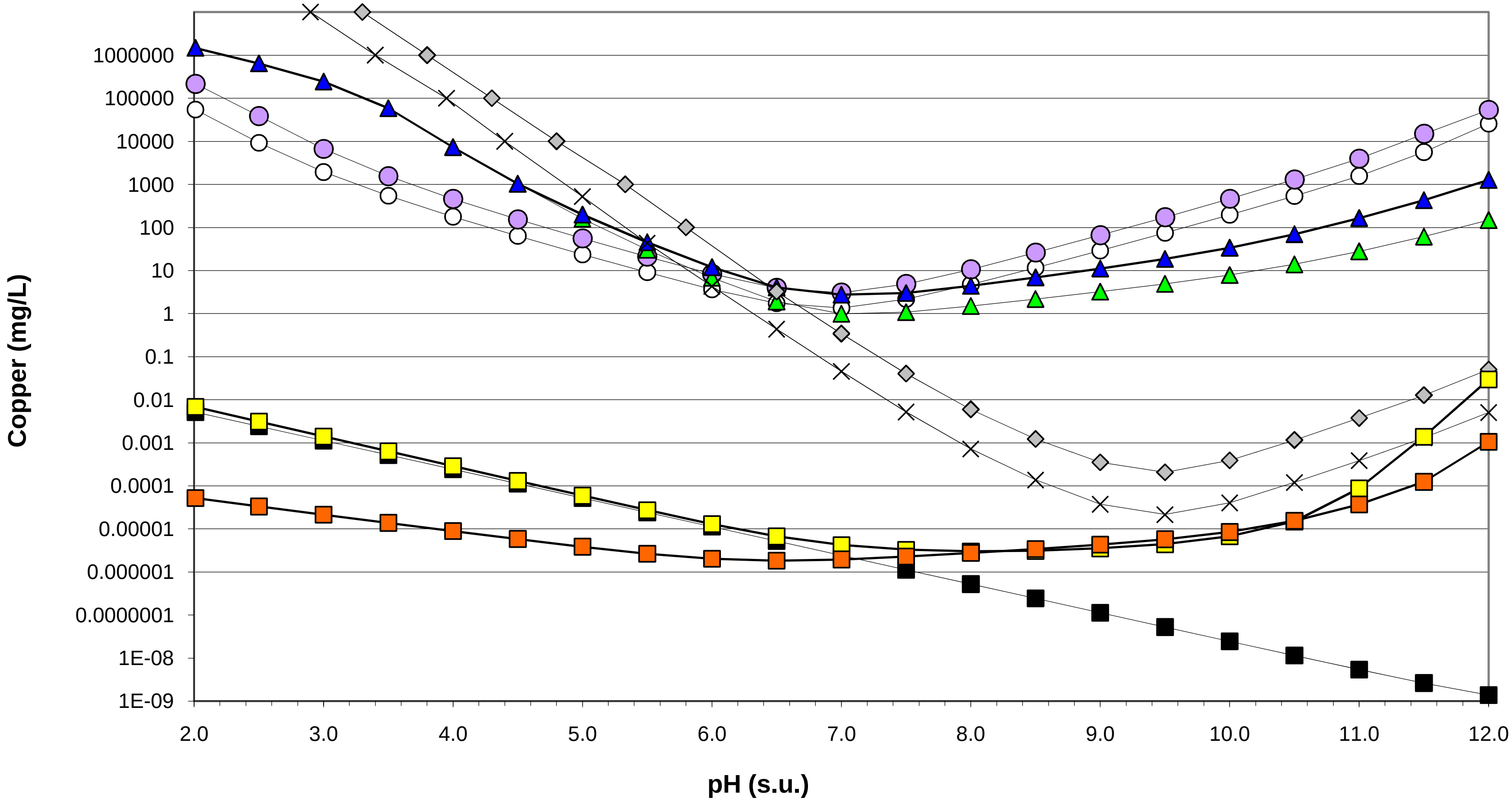
FIGURE **3-2**

DISTRIBUTION OF COPPER CONCENTRATIONS IN HURLEY

CHINO MINES

07392553F01.mxd | 3/13/2008 | SMARXEN

Golder Associates



Golder Associates

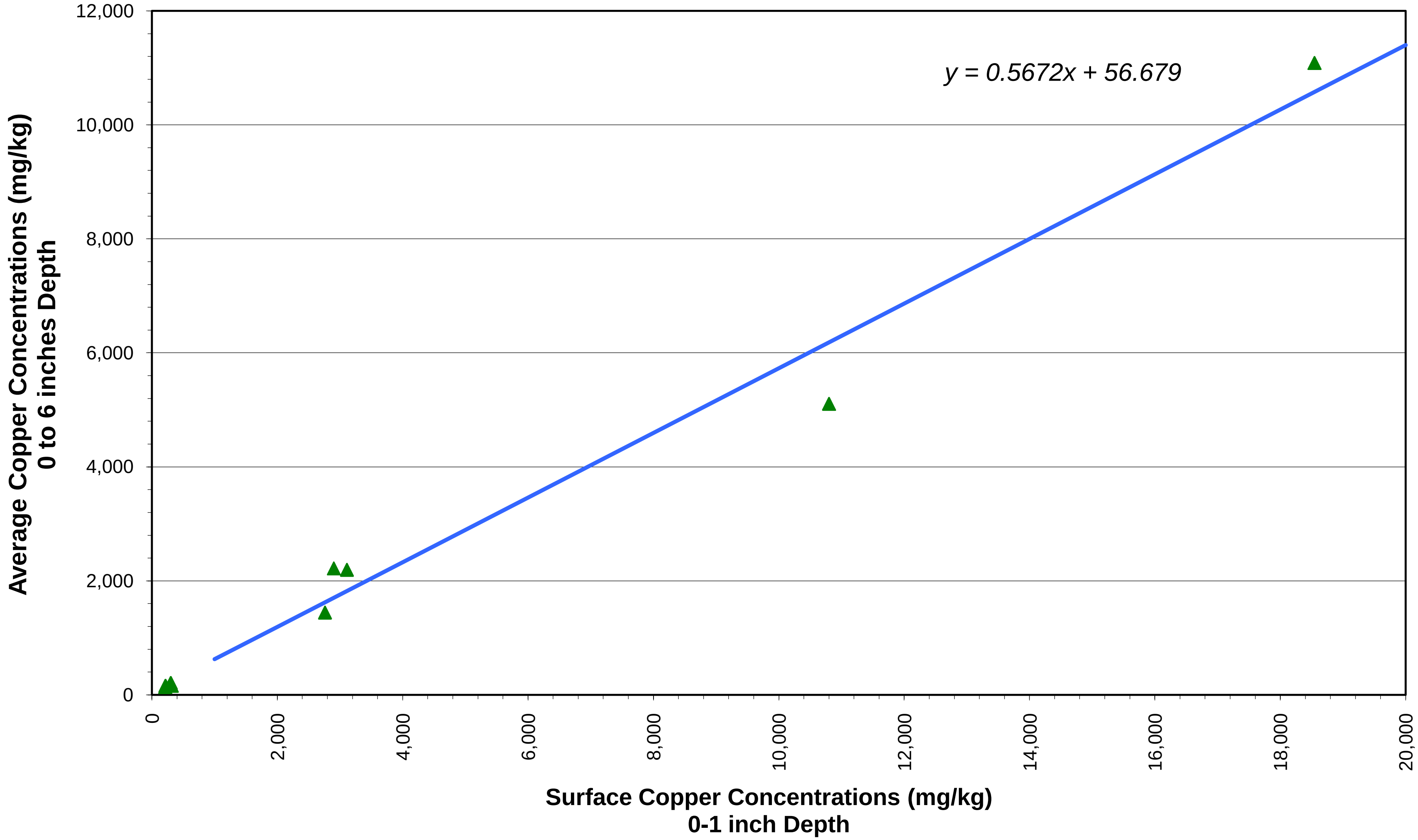
Chino Mines Company
Hurley Feasibility Study

Cu3(PO4)2
Cu3(PO4)2:3H2O
Malachite [Cu2(OH)2CO3]
Azurite [Cu3(OH)2(CO3)2]
Cu(OH)2
Tenorite [CuO]
Cu Metal
Chalcopyrite [CuFeS2]
Covellite [CuS]

Solubility Curves of Selected Copper Species

JOB NUMBER: 073-92553-11.200		DATE:	03/14/05
DRAWN BY:	KS	FIGURE NO.	**4-1**

File Name: Figure 6-1.xls



Golder Associates

Chino Mines Company
Hurley Soils Investigaiton

Measured Copper Concentrations

Predicted Copper concentrations

Comparison of Copper Concentrations at Surface to Projected Concentrations after Tilling

JOB NUMBER:	073-92553-11.200	DATE:	3/14/08
DRAWN BY:	DGC	FIGURE NO.:	**6-1**

APPENDIX A

COST ESTIMATES

Pilot Program Cost Summary

HSIU Residential Properties Remedial Action

Week Ending 7/24/05		**Week Ending 7/31/05**		**Week Ending 8/07/05**		**Week Ending 8/14/05**		**Week Ending 8/21/05**	
Labor		**Labor**		**Labor**		**Labor**		**Labor**	
Regular	$2,325	Regular	$2,878	Regular	$3,222	Regular	$3,300	Regular	$3,063
Overtime	$158	Overtime	$64	Overtime	$128	Overtime	$207	Overtime	$854
Raw Labor Subtotal	$2,482	Raw Labor Subtotal	$2,942	Raw Labor Subtotal	$3,350	Raw Labor Subtotal	$3,507	Raw Labor Subtotal	$3,917
Overhead and Profit	$1,662	Overhead and Profit	$2,014	Overhead and Profit	$2,285	Overhead and Profit	$2,377	Overhead and Profit	$2,568
Labor Total	$4,144	Labor Total	$4,956	Labor Total	$5,636	Labor Total	$5,884	Labor Total	$6,485
Equipment		**Equipment**		**Equipment**		**Equipment**		**Equipment**	
Equipment Total	$1,763	Equipment Total	$2,299	Equipment Total	$3,108	Equipment Total	$3,240	Equipment Total	$2,759
Materials		**Materials**		**Materials**		**Materials**		**Materials**	
Backcharges Subtotal	$0	Backcharges Subtotal	$2,614	Backcharges Subtotal	$457	Backcharges Subtotal	$1,639	Backcharges Subtotal	$4,719
Markup	$0	Markup	$261	Markup	$46	Markup	$164	Markup	$472
Materials Total	$0	Materials Total	$2,876	Materials Total	$503	Materials Total	$1,803	Materials Total	$5,191
Weekly Total		**Weekly Total**		**Weekly Total**		**Weekly Total**		**Weekly Total**	
Labor, Equip, and Mat Total	$5,907	Labor, Equip, and Mat Total	$10,130	Labor, Equip, and Mat Total	$9,246	Labor, Equip, and Mat Total	$10,926	Labor, Equip, and Mat Total	$14,435
Sales Tax	$351	Sales Tax	$601	Sales Tax	$549	Sales Tax	$649	Sales Tax	$857
Invoice Total	$6,258	Invoice Total	$10,732	Invoice Total	$9,795	Invoice Total	$11,575	Invoice Total	$15,292
Total Project Cost	**$53,652**								
Number of Properties	4								
Average Cost per Property	**$13,413**								

Pilot Program Material Costs

HSIU Residential Properties Remedial Action

	Item	Units	Unit Price	Quantity	Cost
Invoices:					
Ending 7/31					
	Pavers	each	$1.25	240	$300.00
	Mortar Mix	60 lb bags	$3.89	2	$7.78
	Tools	each	$2.99	1	$2.99
	#8 Bright Scoffold Nails	lb	$0.99	19	$18.81
	Landscaping Bricks	each	$3.19	90	$287.10
	1" Landscape Gravel	ton	$14.38	138.92	$1,997.67
				Subtotal	$2,614.35
Ending 8/07					
	Tiller rental	per day	$56	1	$56.24
	Nails	lb	$1.50	14	$21.00
	1" Landscape Gravel	ton	$14.38	26.4	$379.63
				Subtotal	$456.87
Ending 8/14					
	Weed barrier	each	$312	4	$1,248.00
	3/4" Landscape Gravel	ton	$14.44	7.03	$101.51
	Dog kennel, bolts, etc.	each	-	-	$289.49
				Subtotal	$1,639.00
Ending 8/21					
	PVC Pipe		-	-	$37.37
	PVC Pipe		-	-	$61.70
	PVC Pipe		-	-	$4.27
	Landfill fee	ton	$43.00	0.66	$29.79
	1" Landscape Gravel	ton	$12.94	23.42	$303.05
	1" Landscape Gravel	ton	$14.38	45.13	$648.97
	1" Landscape Gravel	ton	$16.26	38.94	$633.16
	3/4" Landscape Gravel	ton	$17.26	12.80	$220.93
	Diesel Fuel		-	-	$360.08
	Sod	sq ft	$0.22	11,000	$2,420.00
				Subtotal	$4,719.33
	Total Backcharged Materials				$9,429.55

Soil Cover Monitoring and Maintenance

Duration of Maintenance Period		30	years	
Discount Rate*		5.0%		
	Cost			
Activity	(2007$)			
Monitoring	$550			
Maintenance	$1,100			**Net Present**
				Value*
Year After Remediation	**Monitoring**	**Maintenance**	**Raw Cost**	**(2007$)**
1	$550	-	$ 550	$ 524
2	$550		$ 550	$ 499
3	$550	-	$ 550	$ 475
4	$550	-	$ 550	$ 452
5	$550	$1,100	$ 1,650	$ 1,293
6			$ -	
7	$550		$ 550	$ 391
8			$ -	
9	$550		$ 550	$ 355
10		$1,100	$ 1,100	$ 675
11	$550		$ 550	$ 322
12			$ -	
13	$550		$ 550	$ 292
14			$ -	
15	$550	$1,100	$ 1,650	$ 794
16			$ -	
17			$ -	
18			$ -	
19			$ -	
20	$550	$1,100	$ 1,650	$ 622
21			$ -	
22			$ -	
23			$ -	
24			$ -	
25	$550	$1,100	$ 1,650	$ 487
26			$ -	
27			$ -	
28			$ -	
29			$ -	
30	$550	$1,100	$ 1,650	$ 382
Total PV Cost				**$ 7,562**

**Projected Costs adjusted for 5% annual discount rate for 2007 dollars*